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LINEAR NOISE-ATTENUATING EARPHONE.(U)
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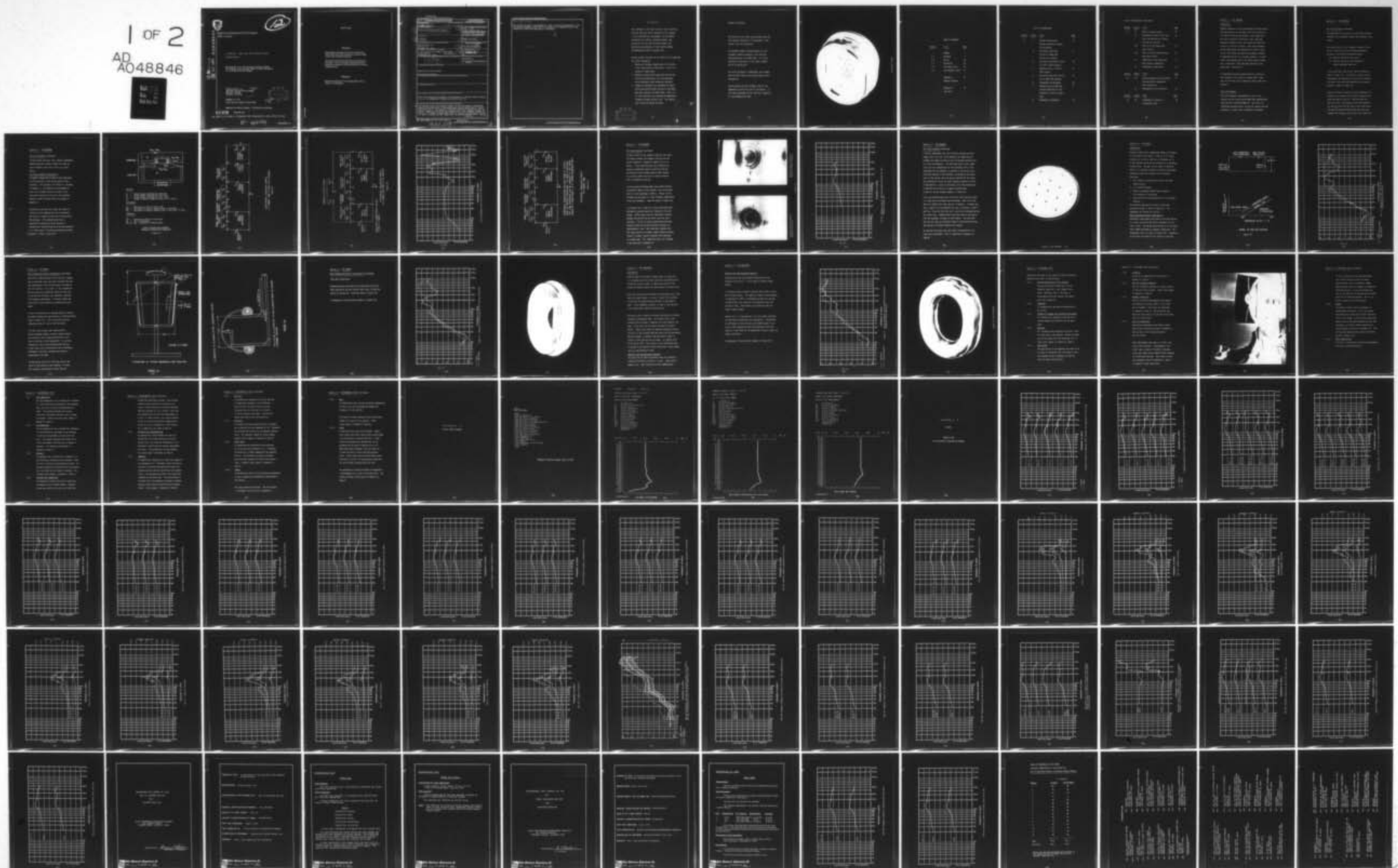

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Research and Development Technical Report

ECOM- 76-0149-R

LINEAR NOISE-ATTENUATING EARPHONE

New earphone fits 8 dB frequency response envelope in an earcup which provides superior noise attenuation in a 115 dBA noise environment.

Electro-Voice, Inc.
Military Engineering Department
600 Cecil Street
Buchanan, MI 49107

New

November 4, 1977

Final and Only Report of Work Done

Approved for Public Release. Distribution Unlimited.

ECOM

Prepared for:

US ARMY ELECTRONICS COMMAND FORT MONMOUTH, NEW JERSEY 07703

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This document covers the technical details of work performed to improve the linearity and attenuation of the earphone and earcup respectively in Flying Type Helmet SPH-4. The results of the effort provide an immersible, salt resistant, rugged and low distortion earphone with a flat frequency respone fitting an 8 dB response envelope when placed in the newly designed earcup which is lighter in weight but more rugged than the present standard SPH-4. The new (cont'd)

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ear-cushion utilizes a low permeability foam for improved attenuation in the low and mid-frequency range, which is covered with a urethane film for low temperature flexibility and body oil resistance.

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1473B

S U M M A R Y

This document is the final and only report resulting from the technical effort expended by this company in the investigation, development, and laboratory production of an earcup, earphone element, and earcushion for use with the SPH-4 Helmet, and meeting the requirements of Specification Number EL-CP0182-0001A dated 14 October 1975.

Briefly stated, the goals of our effort can be separated into three categories.

1. Develop an earphone element which will provide a flat sound pressure from 200 Hz - 6 kHz in an earcup on a human head.
2. Develop an earcup which when used with the earcushion described below, will provide better noise attenuation than heretofore obtained.
3. Develop an earcushion to complement the above earcup and provide better sealing to the human head than cushions available today. Also, try to find a material less affected by temperature extremes and body and hair oils. The cushion cover should be fungus resistant.

Summary (continued)

The results of our effort are provided under the three general headings of "The Earphone", "The Earcup", and "The Earcushion."

The earphone element developed meets an 8 dB frequency response envelope in the specially developed earcup on a human head. It is also immersible, impervious to salt spray, rugged, and of low distortion.

The earcup designed is lightweight, more rugged than the SPH-4 earcup and provides better noise attenuation.

The earcushion utilizes urethane film for low temperature flexibility and oil resistance. It also takes advantage of the "slow set" properties of "low permeability foam."

NEW EARCUP DESIGN

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Section 1.1 - THE EARPHONE

Introduction

Dynamic earphones of the type produced by Electro-Voice have been used by all branches of military service in all types of earcups and helmets. Even though they are used in earcups of different sizes, they have frequency response, level, and distortion specified, using a 6 cc acoustic coupler. When these earphone-earcup combinations are measured on a person's head or on a flat plate, the resulting frequency response is degraded from the 6 cc coupler response. In particular, the earphone used in the SPH-4 headset system has a substantial 4 kHz peak when measured on the human head. See Figure 4.

A replaceable earphone element which will deliver a flat response in an earcup on a human head is the goal of the first area of technical effort under this contract.

The H-143 Earphone

The first earphone investigated for use in this contract was the Electro-Voice Model 689, manufactured under Military Contract ASANH-143. The H-143 is a lightweight earphone which, along with several spin-off earphones, is widely used in headsets and helmets.

Section 1.1 - THE EARPHONE

The H-143 Earphone (continued)

The performance of the H-143, as with other earphone elements, has a degraded response when mounted in the earcup.

Our investigation of the frequency response of the H-143, as detailed in the following paragraphs, resulted in two significant modifications:

(1) Acoustic sealing of rear cavity

(2) Acoustic loading of the diaphragm to reduce diaphragm "break up."

A cross-sectional view of this type of earphone is shown in Figure (1). An electrical analog circuit representing the mechanical and acoustical elements utilized in the H-143 when measured on an acoustic coupler is shown in Figure (2).

Figure (3) shows an analog of a H-143 earphone as it performs in an earcup with no baffle separating the front and rear of the unit. Note that Mp2 and Rp2, the "leak", now couples to the same volume as M_{FC} and R_{FC} which are the holes in the front cover. The phase difference between these two pressures changes with frequency and causes a small peak with

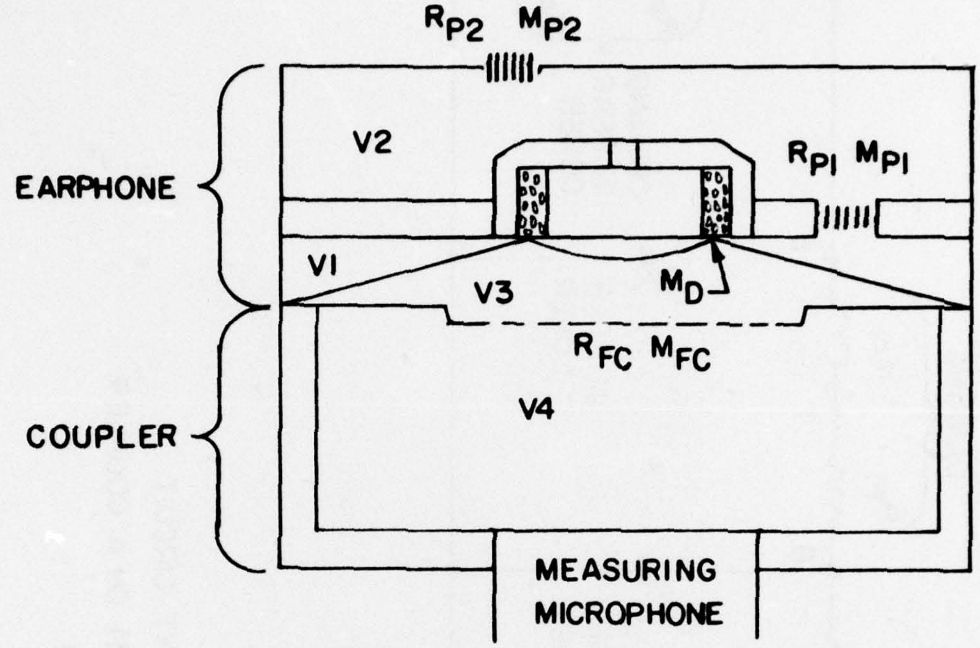
The H-143 Earphone (continued)

rolled off bass end much like a vented loudspeaker. Demonstrating this effect, Figure (4) shows an actual response curve of an H-143 in an SPH-4 earcup.

The Linear Earphone Investigation

A computer program was written to help understand the interrelation of the various parts of the earphones. This program in GE "BASIC" is included in Appendix A. The computer was programmed to print out a response curve as a check on the equivalent electrical circuit for the earphones. Computer curves are shown after the program in Appendix A.

By making Mp2 and Rp2 very large, the effect of closing the rear damping hole can be simulated. The result is a model similar to an Electro-Voice 986 earphone. This earphone which has an acoustically sealed rear cavity exhibits a smoother bass response than the H-143 when measured in a large earcup. An analog representing the 986 earphone is shown in Figure (5).



CAVITIES

V_1 = Volume between diaphragm and faceplate.
V_2 = Volume between faceplate and rear cover.
V_3 = Volume between diaphragm and front cover.
V_4 = Volume of acoustic coupler (either 6 cc or 150 cc).

RESISTANCES

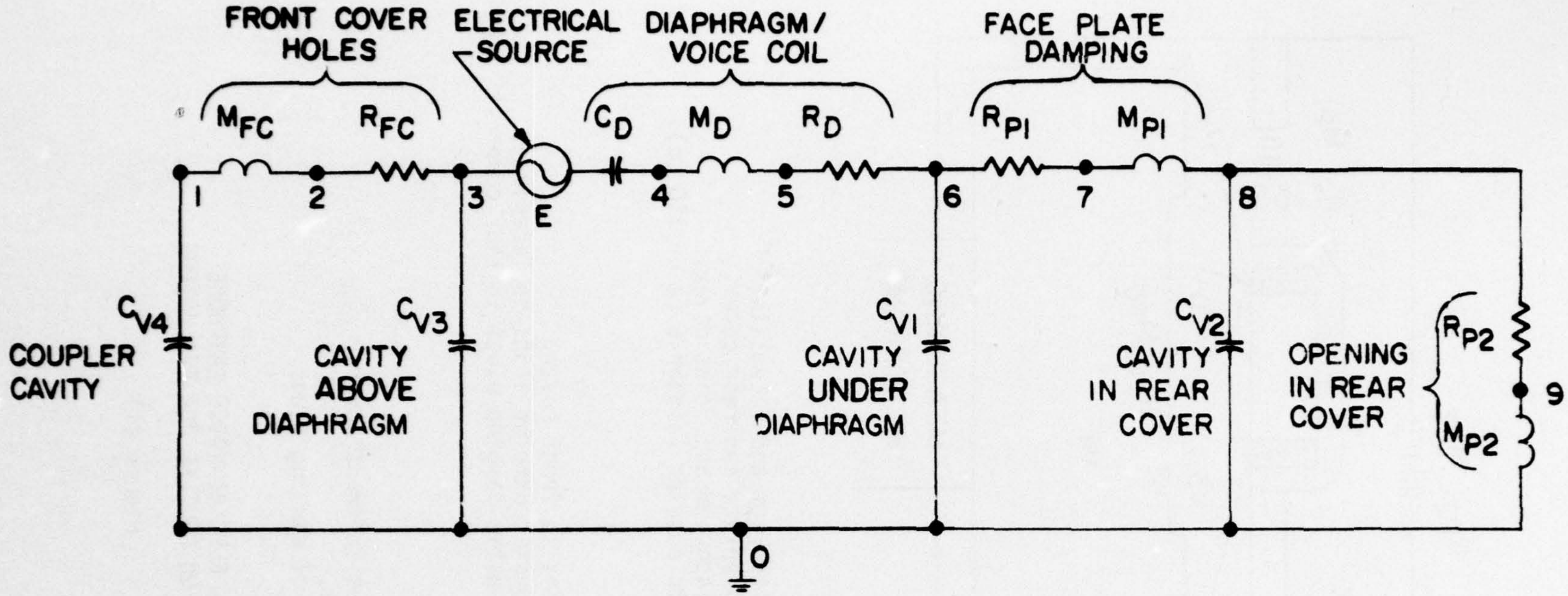
R_{fc} = Resistance of holes in front cover.
Rp_1 = Resistance of acoustic damping plugs in faceplate.
Rp_2 = Resistance of acoustic damping plugs in rear cover (if any).

INERTANCES

M_{fc} = Inertance of holes in front cover.
Md = Mass of diaphragm.
Mp_1 and Mp_2 = Inertances of damping plugs.

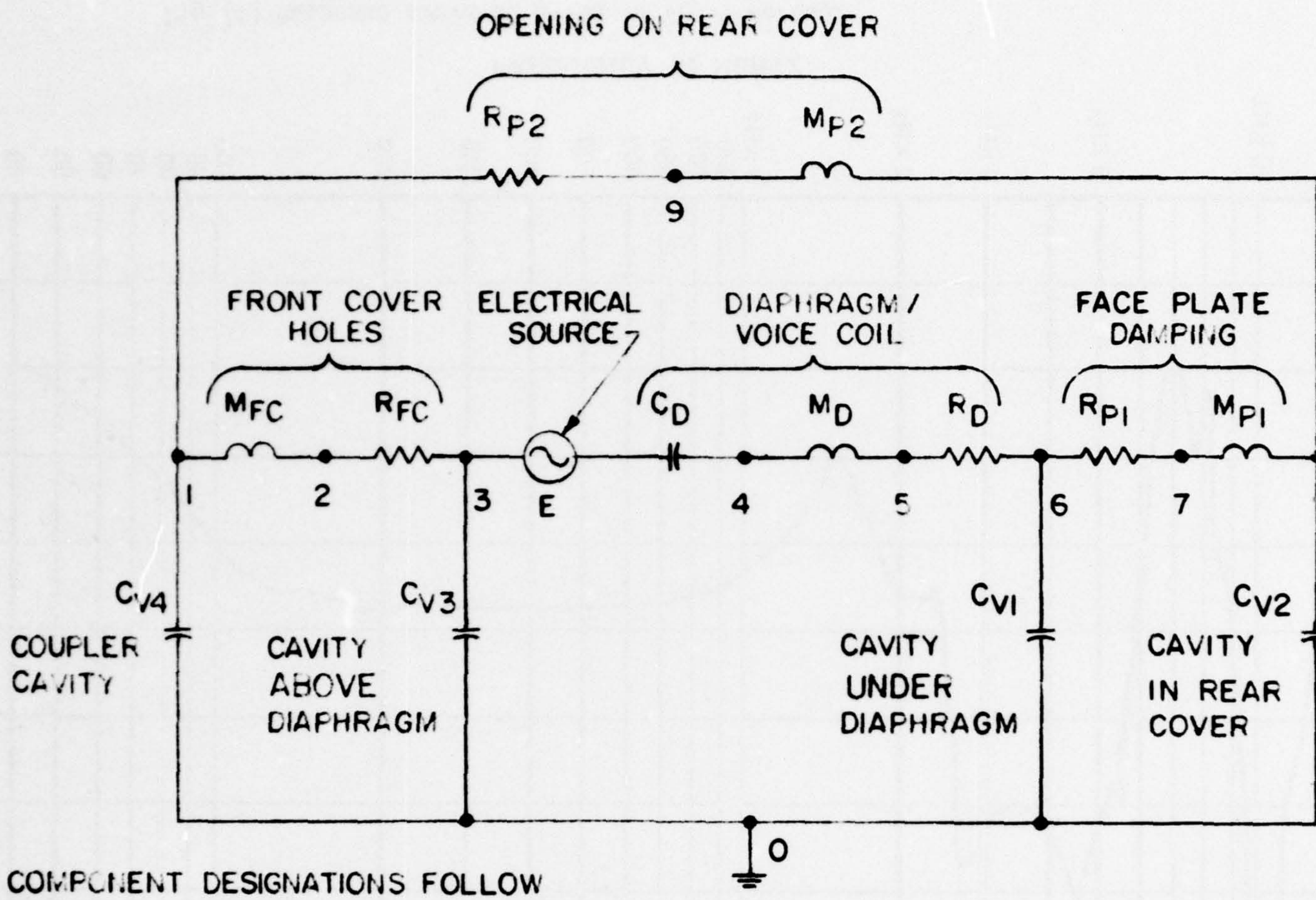
TYPICAL ELECTRO-VOICE EARPHONE
MOUNTED ON COUPLER FOR EVALUATION

Figure (1)



ELECTRICAL EQUIVILANT CIRCUIT
E. V. MODEL 689 (H-143) ON A COUPLER

Figure (2)



COMPONENT DESIGNATIONS FOLLOW THOSE IN FIGURE 1.

ELECTRICAL EQUIVILANT CIRCUIT
E.V. MODEL 689 (143) IN AN EARCUP

Figure (3)

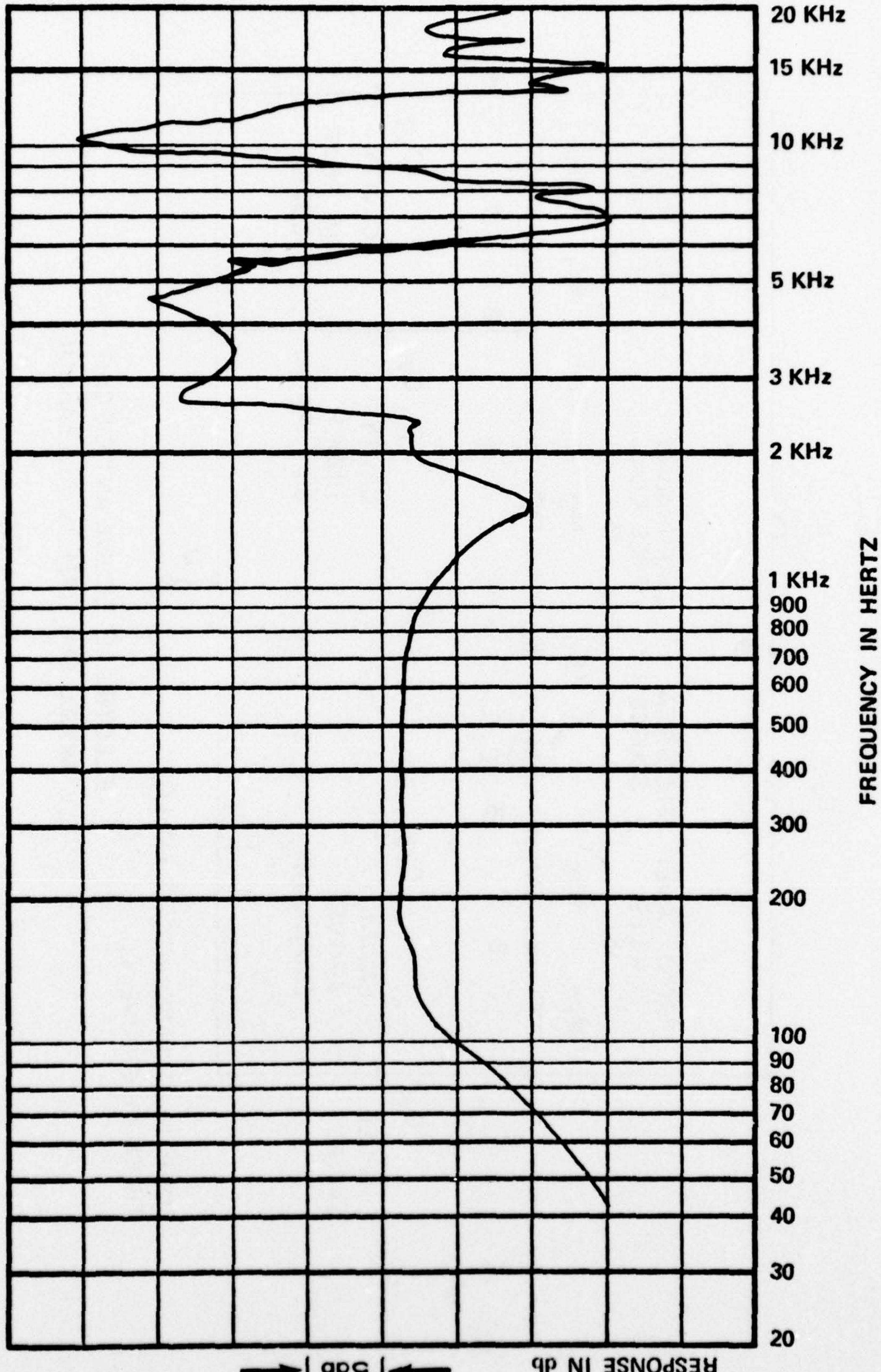
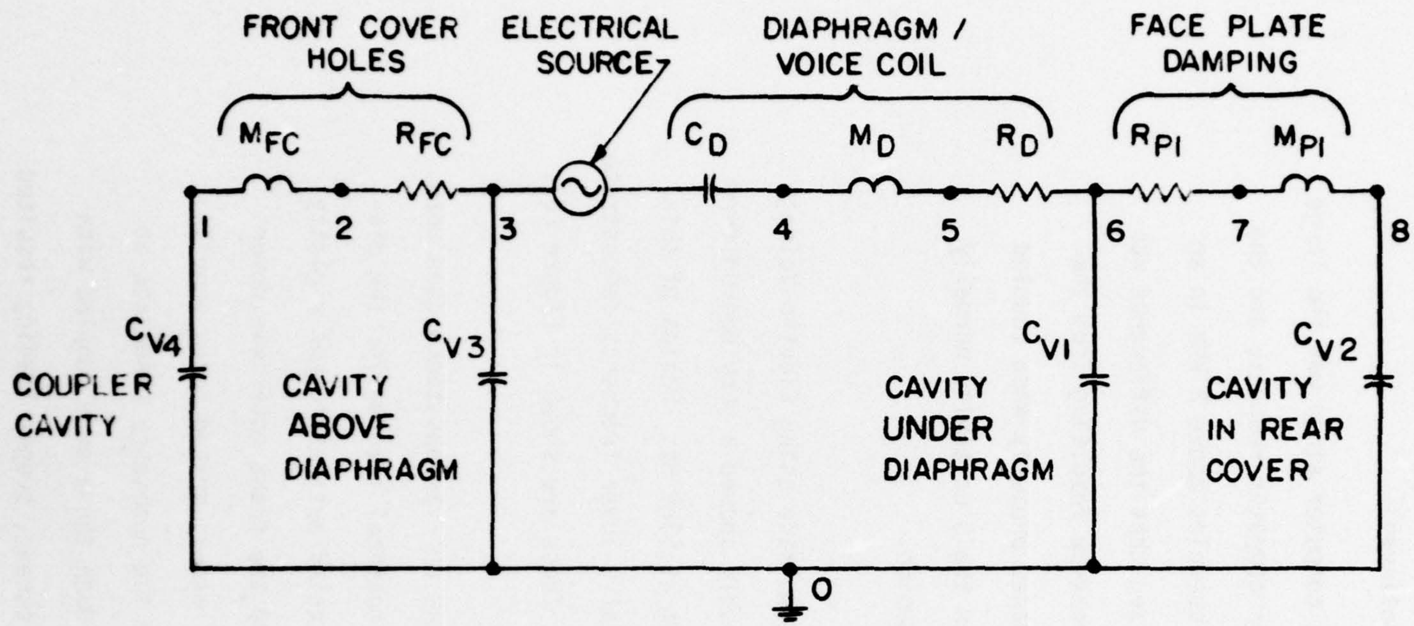


Fig. (4) Response curve of H-143 in SPH-4 earcup.

Fig. (4)



COMPONENT DESIGNATIONS FOLLOW THOSE IN FIGURE 1. NOTE NO BRANCH FROM NODE 1 TO NODE 8 BECAUSE THE 986 EARPHONE HAS NO OPENING IN THE REAR COVER AS IT MUST PASS A 3 FT. WATER IMMERSION TEST.

ELECTRICAL EQUIVILENT CIRCUIT
E. V. MODEL 986

Figure (5)

Section 1.1 - THE EARPHONE

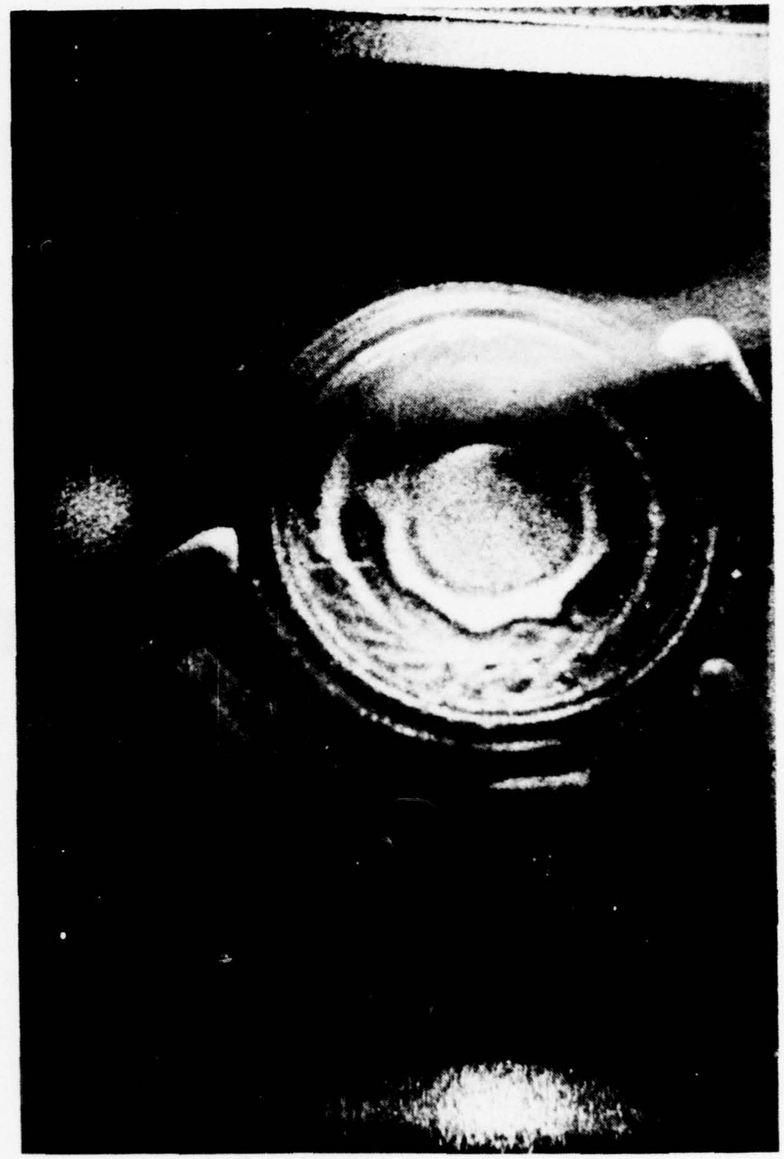
The Linear Earphone (continued)

A second result of the computer study was the large discrepancy between the computer response and the actual response at frequencies above 2 kHz in an earcup. It was theorized that the difference was caused by diaphragm break-up resulting from the diaphragm not being loaded properly when coupled to a cavity larger than the 6 cc cavity normally used in earphone evaluation.

A time averaging hologram made using Electro-Voice's holographic camera vividly showed a very non-uniform motion in the diaphragm at 5369 Hz. Photos of this hologram and one made at a lower frequency demonstrate "break up" phenomena. These are shown in Figure (6).

To eliminate this "break up" various techniques were employed to provide acoustical loading for the diaphragm. Baffles were tried but sufficient rigidity between the baffles and the front cover was never attained. A series of widely spaced holes provided greater dispersion and the necessary resonance at approximately 5 kHz. When these were coupled with the right porosity of screen, proper loading resulted. Figure (7) shows a typical response curve measured on a human head. The remaining curves are included in the test data in Appendix B.

Hologram showing diaphragm
operating as piston.



Hologram showing diaphragm
breakup at higher frequency.

FIGURE (6)

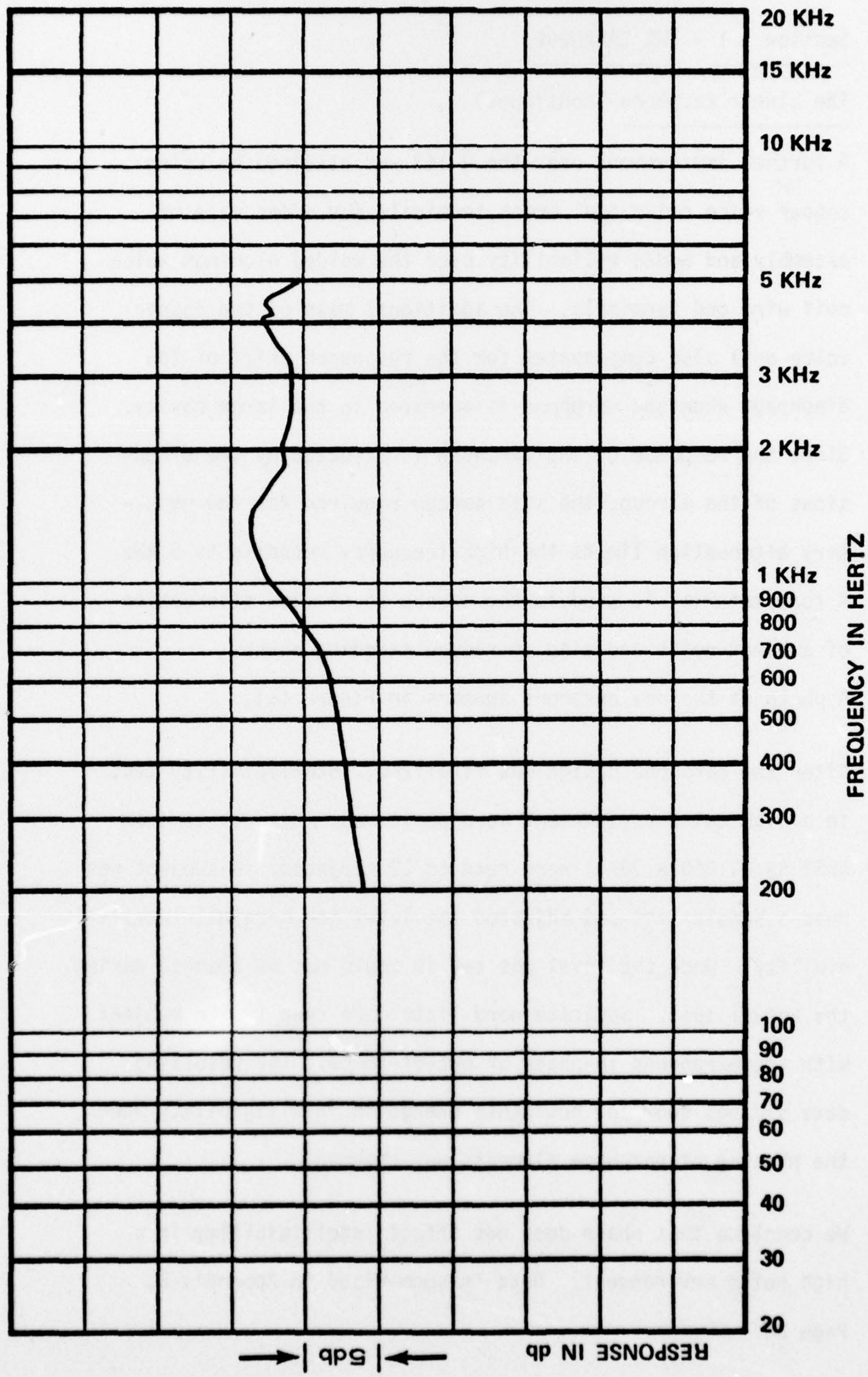


Fig.(7) Response curve of 986-type earphone modified for flat response on human head.

Fig. (7)

Section 1.1 - THE EARPHONE

The Linear Earphone (continued)

A further improvement over the H-143 was attained by using copper voice coils and brass terminals for added ease of assembly and added reliability over the welded aluminum voice coil wire and terminals. The additional mass of the copper voice coil also compensates for the resonance shift of the diaphragm when the earphone is operated in the large cavity. Since the response of the earphone is affected by the dimensions of the earcup, the size earcup required for the necessary attenuation limits the high frequency response to 5 kHz. A foam material is used in the earcup to provide attenuation of ambient noise and also to reduce standing waves. A photo of the new earphone appears in Figure (8).

After the earphone design was finalized, intelligibility tests in a high noise environment were performed. Word lists from ANSI S3.2-1960(R 1971) were read to 12 subjects. A subject was read a sample list and adjusted the level for marginal intelligibility. Once the level was set it could not be changed during the actual test. Separate word lists were read to the subject with the earphones in-phase or out-of-phase. The resulting data did not show any noticable change in intelligibility when the phasing of earphone elements was changed.

We conclude that phase does not affect intelligibility in a high noise environment. Data is summarized in Appendix B, Page 88.

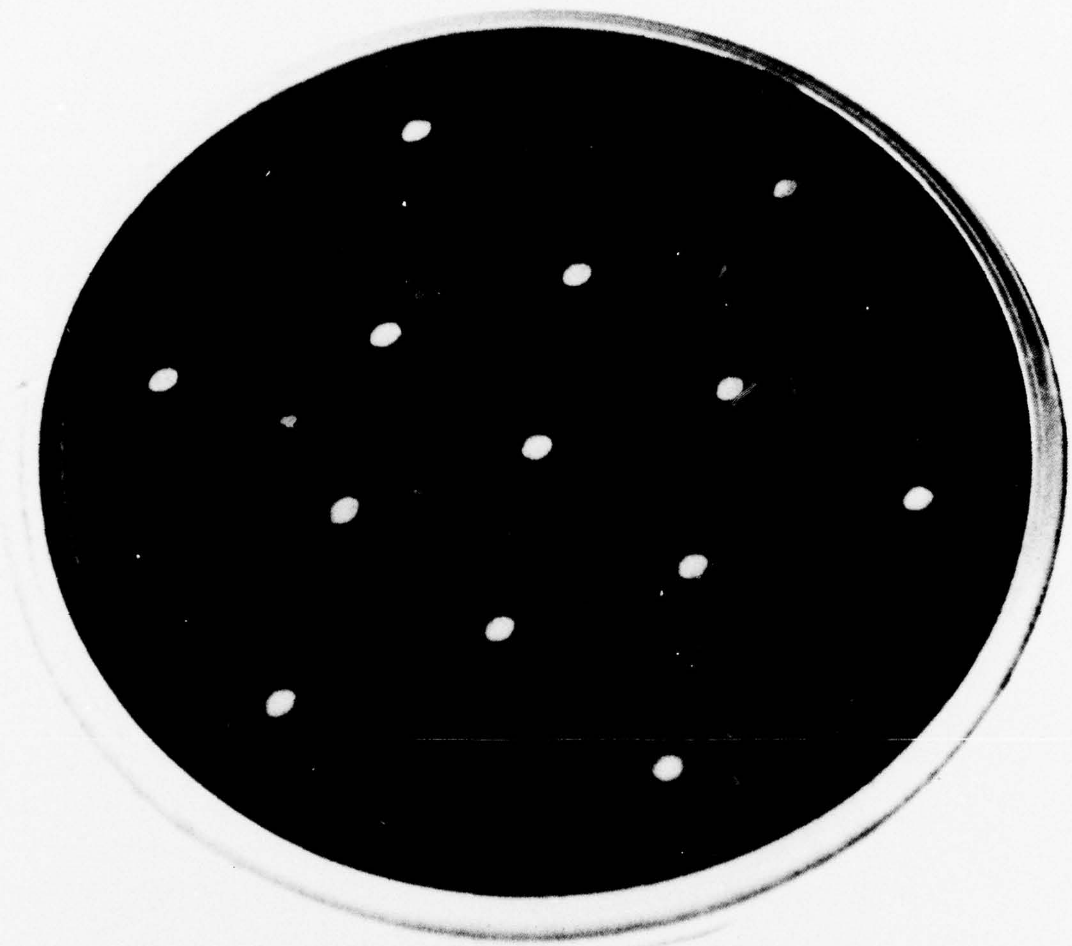


FIGURE (8) NEW EARPHONE (19)

Section 1.2 - THE EARCUP

Introduction

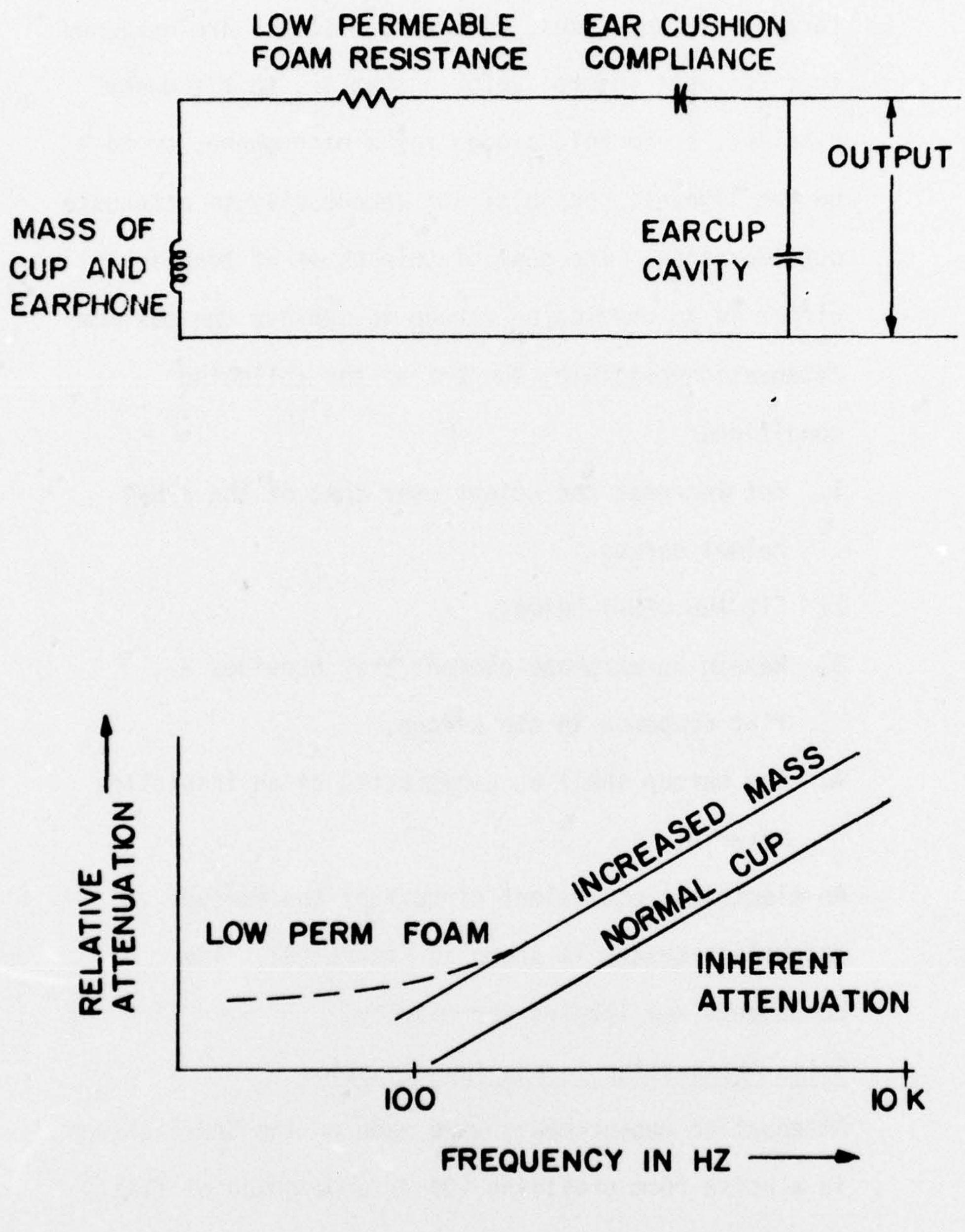
Earcups of many sizes, weights, and shapes are designed to first meet a form factor - that is, to fit under a helmet, or to hold a boom for a microphone, or to be the lightest possible; and secondarily to attenuate outside noise. The goal of this phase of technical effort is to develop an earcup to achieve the maximum attenuation possible, subject to the following conditions:

1. Not increase the weight over that of the SPH-4 helmet earcup.
2. Fit the SPH-4 helmet.
3. Retain an earphone element that provides a flat response in the earcup.
4. The earcup shall be constructed of an insulating material.

An electrical equivalent circuit of the earcup earcushion system is shown in Figure (9). The components are labeled for clarity.

Noise Attenuating Earcup Investigation

Attenuation measurements were made on the SPH-4 earcup in a noise room providing 109 dB unweighted of flat "pink" noise. The earcups were mounted on a flat plate with a 640AA microphone to measure attenuation. The attenuation plots are shown in Figure (10). Inspection of the SPH-4 cup showed a thin section in the area



MODEL OF EAR CUP SYSTEM

Figure (1)

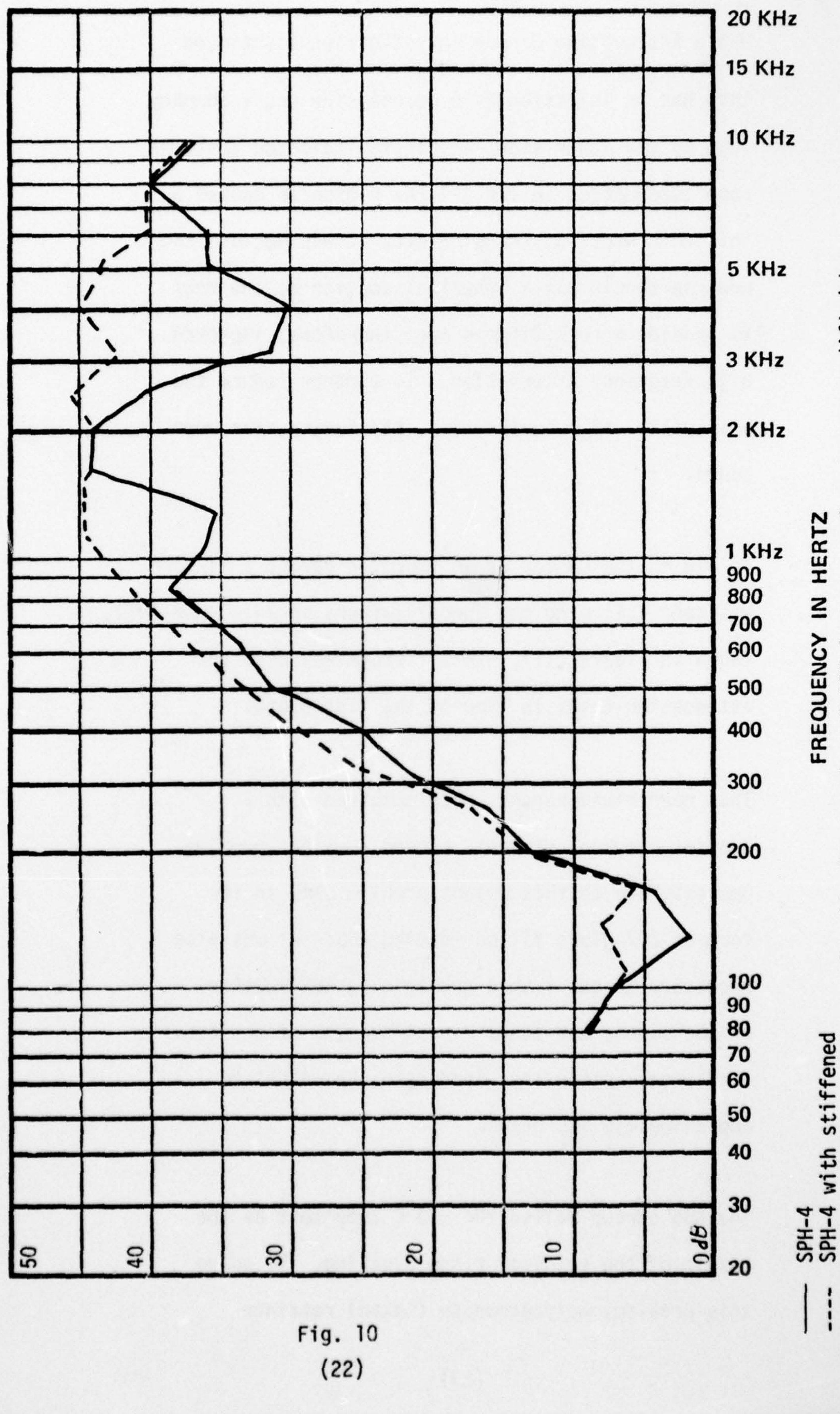


Fig. 10 Attenuation of SPH-4 earcup and an earcup modified by stiffening the rear section.

Fig. 10

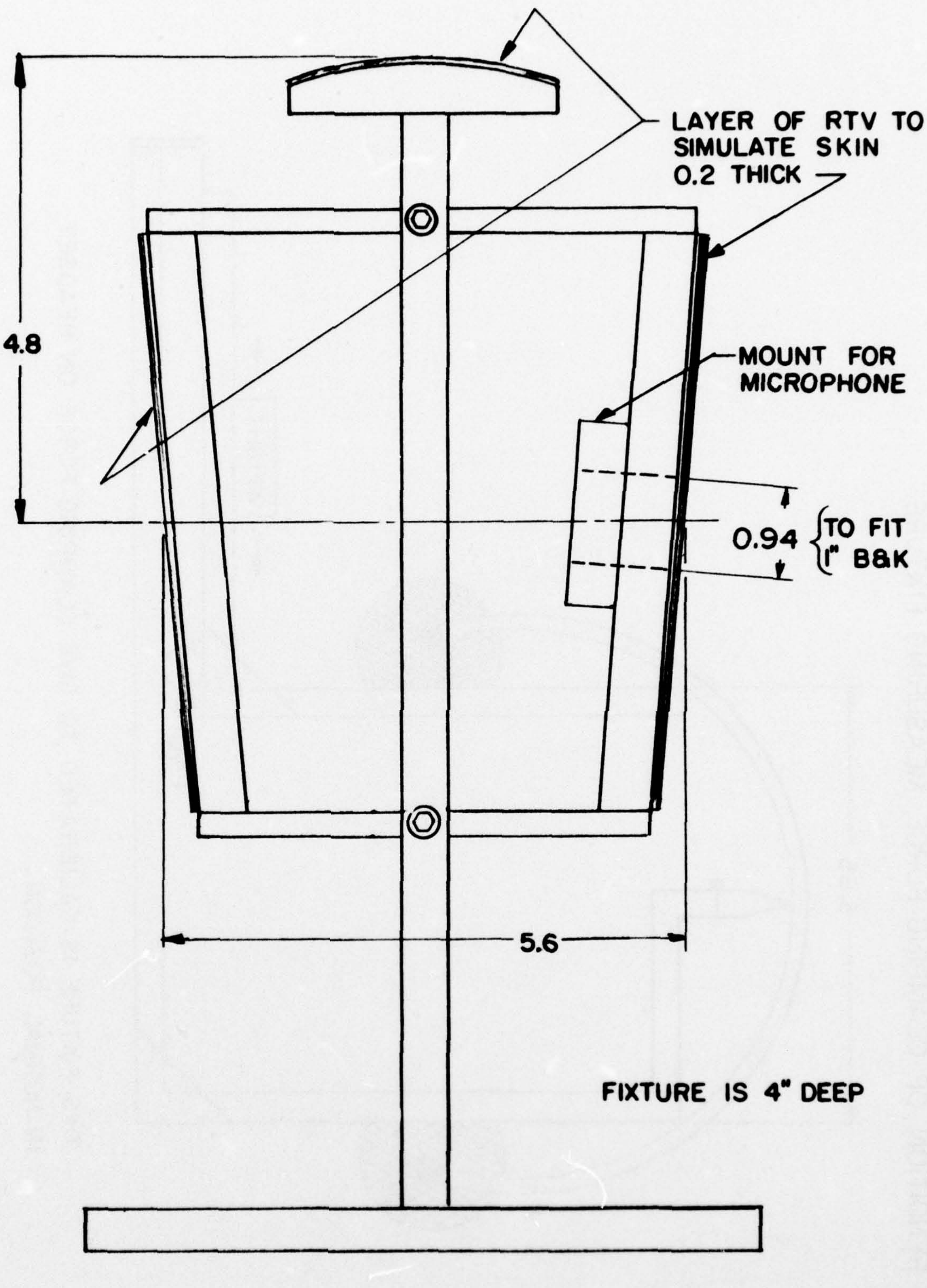
Noise Attenuating Earcup Investigation (continued)

that has an injection gate on one side and a company logo on the other side, and tests indicated that the poor attenuation in the 3-4 kHz region is caused by this thin section. As a result, it was decided the new cup should use a spherical section at the rear to provide more stiffness and, therefore, improved high frequency attenuation. To further reduce the possibility of cup vibration, stiffening ribs were added.

To aid in the design of an improved earcup a fixture was made following the specifications in ANSI S3.19-1974, shown in Figure (11). This fixture was used for attenuation tests in lieu of the flat plate.

This more rigid earcup, when combined with a heavier earphone element, caused a weight problem. One solution to this weight problem came in the form of 20% glass filled foaming ABS. It was also necessary to use a thin non-foaming ABS section on the sides, and to eliminate the use of conformal earflanges, since they increased the weight to approximately 180 grams.

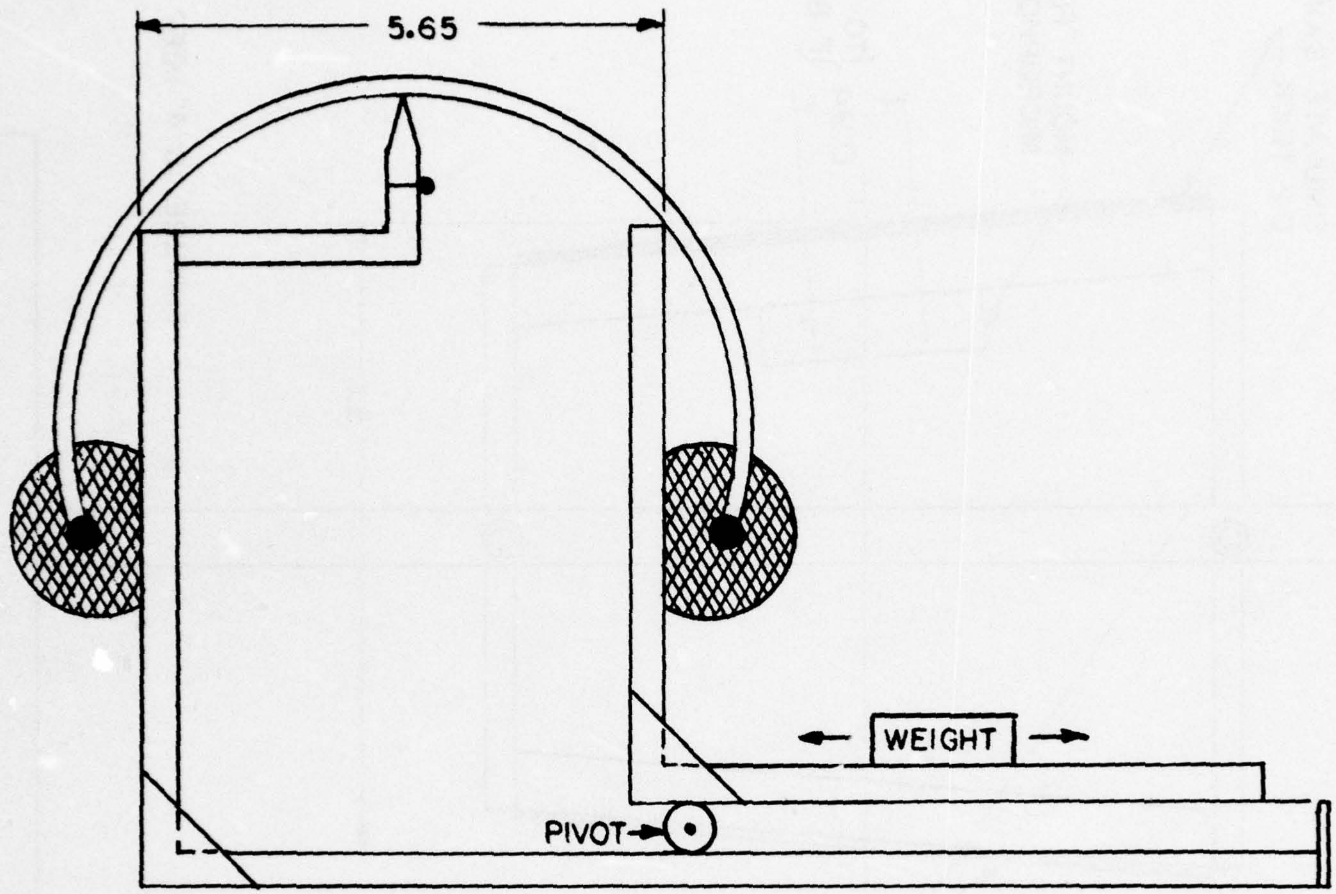
The ABS earcup failed the -40^{o}C drop test as the result of the retainer rings breaking. To solve this problem, polycarbonate (Lexan) retainer



A RENDITION OF FIXTURE DESCRIBED IN ANSI S3.19-1974

FIGURE 11a.

A RENDITION OF CLAMPING FORCE MEASURING FIXTURE.



THIS FIXTURE IS CALIBRATED TO GIVE CLAMPING FORCE ON HEADSET IN NORMAL POSITION.

FIGURE 11b.

Section 1.2 - THE EARCUP

Noise Attenuating Earcup Investigation (continued)

rings were substituted.

Attenuation plots were made of the new earcup using the SPH-4 earcushion and the original SPH-4 cups, to show the effect of the new cup. These are shown in Figure (12).

A photograph of the new earcup appears in Figure (13).

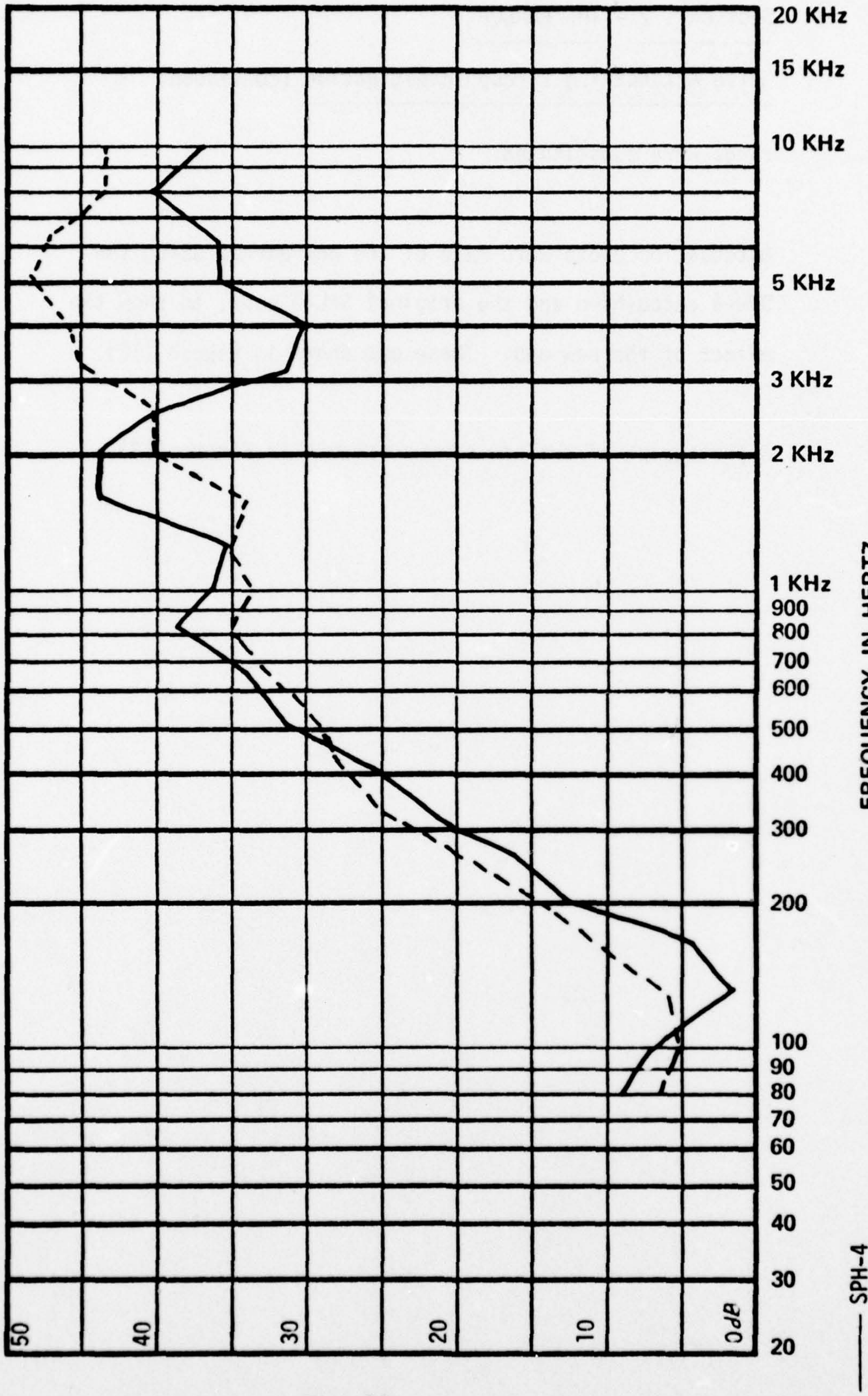


Figure 12 Comparison of new earcup and SPH-4 earcup attenuation.

Fig. 12

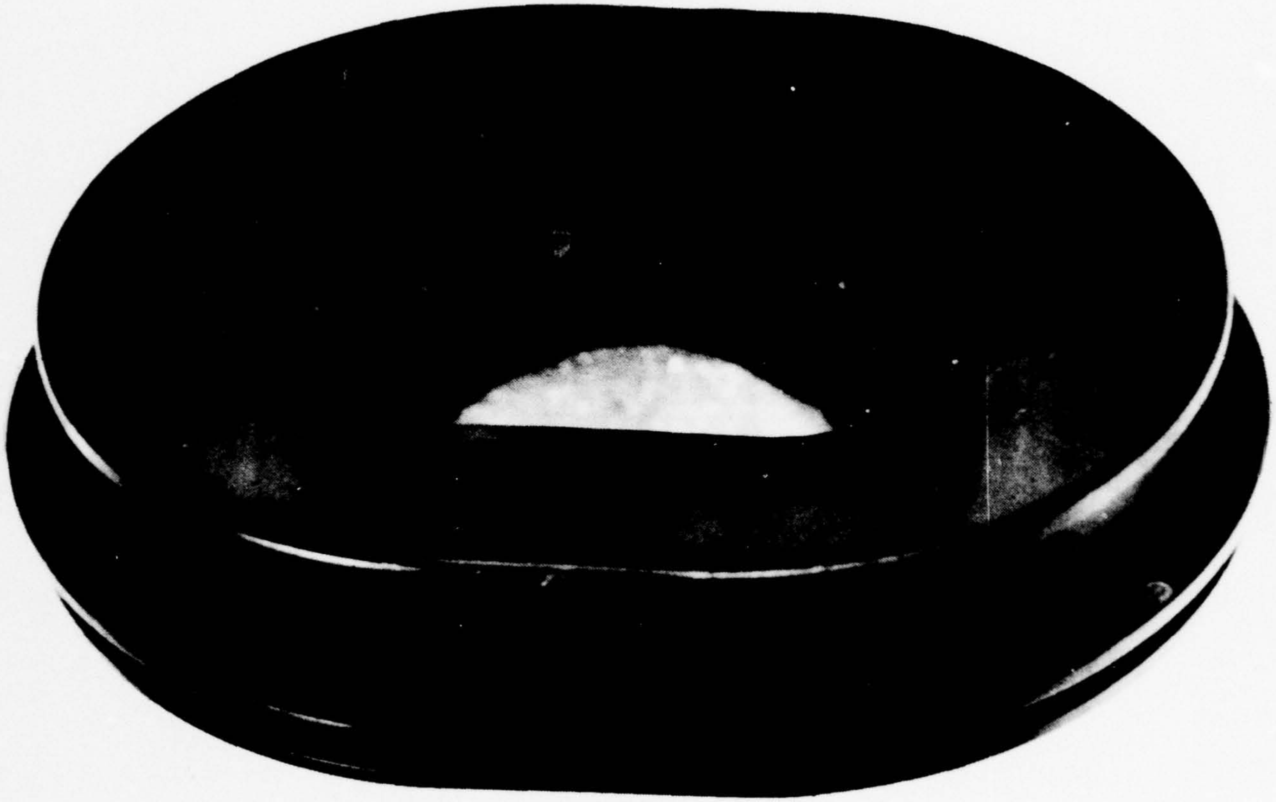


FIGURE (13) NEW EARCUP

Section 1.3 - THE EARCUSHION

Introduction

From the model of the whole system, shown in Figure (9), it is apparent that the series compliance representing the earcushion should be small to reduce the motion of the system and thereby reduce the feed-through of ambient noise.

There are various ways to reduce this compliance; one of the more well-known methods is to use a liquid filled cushion. It provides low compliance and conforms to the wearer's head. It has drawbacks, however, in that it can leak and it has undesirable thermal characteristics.

We chose to use a recently available foam known as Low-Perm polyether polyurethane foam. This material has a slow recovery time and takes a temporary set once placed on the head. It has very low resilience and tends to inhibit motion. Figure (14) shows the improved attenuation characteristics of the Low-Perm foam when used with the new earcup When the headset is removed from the wearer's head, it returns to the original die cut shape. It retains flexibility below -25^{O}F. The cushion is very comfortable when it adjusts to the wearer's facial shape and it seals better than any other material tried.

Research Into New Earcushion Material

The search for an ideal earcushion cover was started by examining the faults of vinyl as a cover. These faults appear to be: poor flexibility at low temperatures;

Section 1.3 - THE EARCUSHION

Research Into New Earcushion Material

hardening with age; and apparent deterioration with exposure to skin oils. It also tends to support fungus growth.

A literature search located a material which seems to have none of these faults. This material (known as polyurethane) is compliant to -70^{0}C, is unaffected by body oils and has no plasticizer, thus retaining its properties over long periods of time. Additionally, this material does not support fungus growth.

Because this is a new material, it is not widely available and fabrication techniques are experimental. The material, as fabricated for this contract, has demonstrated in our tests a clear superiority over the previously used vinyl material in the areas of low temperature flexing, aging, and fungus resistance.

A photograph of the earcushion appears in Figure (15).

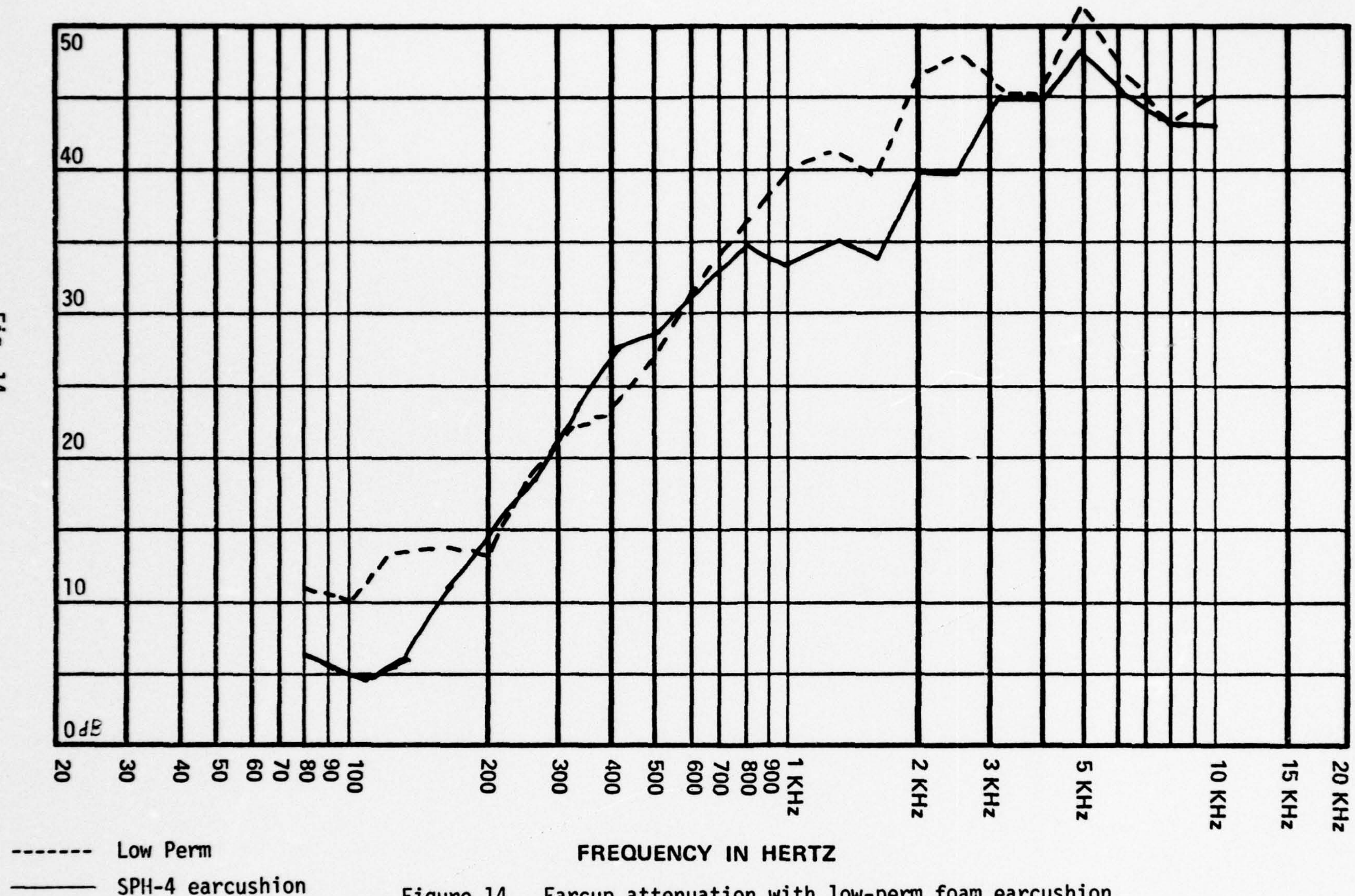


Figure 14 Earcup attenuation with low-perm foam earcushion compared to SPH-4 earcushion.

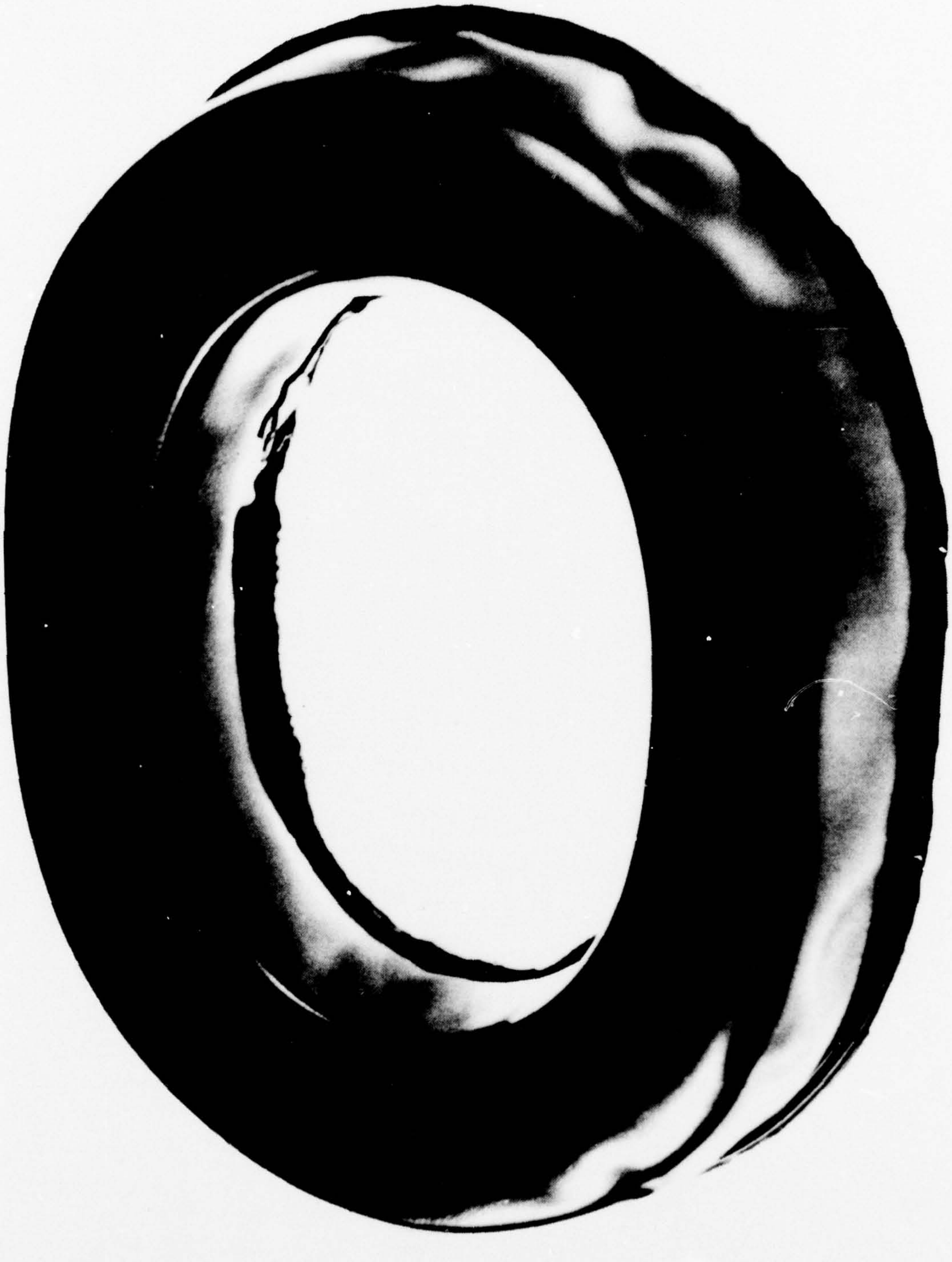


FIGURE (15) NEW EARCUSHION

Section 1.4 - FUNCTIONAL TESTS

Testing was performed on the complete system to determine compliance with Spec. EL-CP0182-0001A.

1.4.1 Earphone Cushion and Filler Material

The cushion material chosen was of a non-hardening type with a slow "memory" which takes a temporary "set." The cover is polyurethane which has superior low temperature flex properties.

1.4.2 Impedance

The impedance was measured and determined to be 19Ω±10%.

1.4.3 Dielectric Strength and Insulation Resistance

The earphone was subjected to 100 Vdc for 10 seconds between the terminals and the metal cover.

1.4.4 Overload

The earphones were subjected to 300 mW @ 1 kHz for eight hours, and retested. Before and after curves show compliance with Paragraph 3.5.1.3. These curves appear in Appendix B, Page 47.

1.4.5 Sensitivity

The sensitivity of the earphones was shown to be in excess of 85 dB SPL with 1 mW input @ 1 kHz. The response curves in Appendix B, Page 49, give the actual sensitivities.

Section 1.4 - FUNCTIONAL TESTS (continued)

1.4.6 Linearity

Linearity is demonstrated by the curves in Appendix B, Page 51.

1.4.7 Real Ear Frequency Response

Real ear frequency response on a typical person is shown for each earphone. These curves appear in Appendix B, Page 49.

1.4.8 Harmonic Distortion

Harmonic distortion measurements were made on the earphone at various levels. At no level was 5% exceeded. The results are tabulated in Appendix B, Page 61. The distortion was below the noise level at 75 dB SPL and has been left out of the graph.

1.4.9 Real Ear Attenuation

Attenuation measurements were made on human heads using a miniature electret microphone in the ear and on the fixture mentioned in ANSI S3.19-1974.

These measurements were made in a "hard" room using a flat spectrum. A photograph of the "hard" room is shown in Figure(16.) Response curves were taken using a General Radio sweeping 1/3 octave band analyzer. The inverse of each curve becomes a plot of attenuation. Page 71 in Appendix B shows these plots.

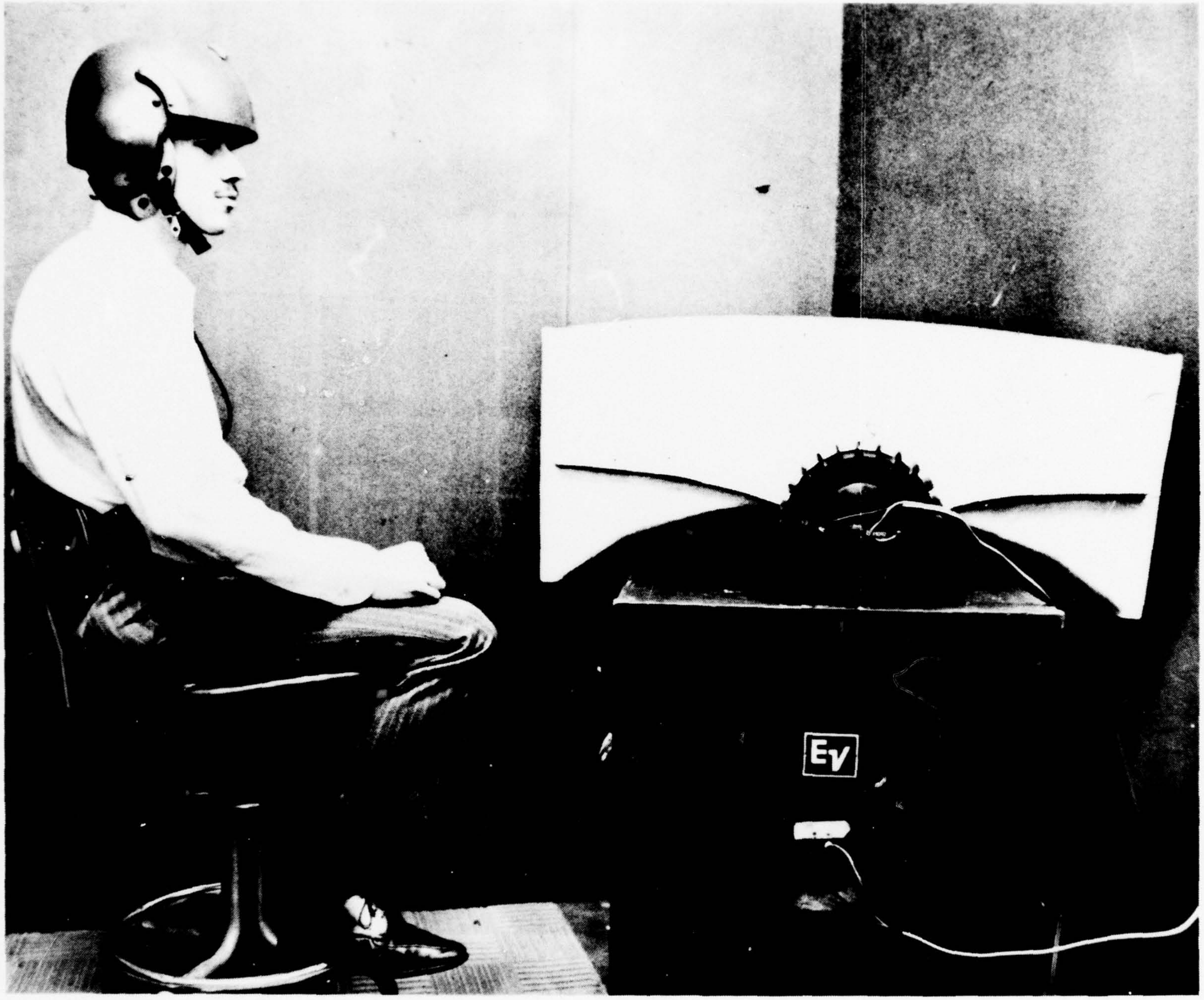


FIGURE (16) SUBJECT IN REVERBERANT ROOM

It is our opinion that the above-mentioned test fixture should be a part of future specifications since it provides a common measuring yard stick for purposes of comparing differing designs. It has one drawback and that is the inability to evaluate the conformal abilities of differing designs. That is, of course, because of the flat surface.

1.4.10 Weight

The weight of each of the 10 prototypes is approximately 145 grams. A 1/4 inch thinner earcushion would yield the 140 grams specified. Since a flat flange is being used to reduce the weight from the 185 grams obtained with our best prototypes, a slightly thicker earcushion is being employed to provide a conformal fit. Also, refining the foaming process should yield more uniform, lighter parts.

1.4.11 Shell Construction

The shell is constructed of ABS and polycarbonate, which are insulating materials.

Section 1.5 - ENVIRONMENTAL TESTS

1.5.1 High Temperature

The high temperature test of Method 501, Procedure II of MIL-STD-810 was performed on one earphone. After the test a sensitivity measurement was taken. The earphone exceeded the minimum sensitivity requirement and there was no change in response. Before and after curves appear in Appendix B, Page 72.

1.5.2 Low Temperature

The low temperature test of Method 502, Procedure I of MIL-STD-810 was performed on one earphone. A sensitivity measurement was made after the test. The earphone exceeded the minimum sensitivity requirement, and there was no change in response. The response curves appear in Appendix B, Page 73.

1.5.3 Humidity

The humidity test of Method 507, Procedure II of MIL-STD-810 was performed on one earphone. After the test a sensitivity measurement was made. The earphone exceeded the minimum sensitivity requirement, and there was no change in response. The response curves appear in Appendix B, Page 74.

1.5.4 Altitude Test (Operating)

An earphone was placed along with a measuring microphone in the altitude chamber. Response curves were taken at sea level and 15,000 and

25,000 feet equivalent altitude. The enclosed response curves show that an earphone in an earcup is more affected by altitude differences than one attached to a 6 cc coupler. While the new earphone does not meet the requirements of 4.3.4.1, it does provide a very usable response which will provide intelligible communication. Curves of an H-143 earphone in a SPH-4 earcup, for a comparison, are shown on Page 75.

1.5.5 Altitude Test (Non-Operating)

An earphone was cycled between sea level and 40,000 feet with 2,500 feet/minute climb and descent rate, five times per Paragraph 4.3.4.2. Afterward a sensitivity and response measurement was taken. The earphone met the requirements. The curves appear in Appendix B, Page 75.

1.5.6 Immersion

An earphone was subjected to a three foot immersion per Paragraph 4.3.5. Afterward, after blowing out the water from behind the perforated screen, the earphone met the required sensitivity and response limits. The earphone was placed in an earcup and subjected to the shock test. The earcup broke in the shock test; the earphone was placed in another earcup and met required sensitivity and response limits. Curves appear in Appendix B, Page 76.

1.5.7 Salt Fog

An earphone was subjected to the salt fog test of Method 509, Procedure I of MIL-STD-810. After 48 hours of exposure the finish was inspected for pits and signs of corrosion. No surface defects were found. The unit was tested and found to work satisfactorily.

1.5.8 Vibration

An earphone and earcup combination was subjected to a vibration test per Paragraph 4.3.10. Afterward the earphone met sensitivity and response requirements. The equipment showed no visible damage. Response curves appear in Appendix B, Page 77.

1.5.9 Shock, Drop

An earphone/earcup combination were subjected to a drop test per Paragraph 4.3.11. Afterward the earcup was slightly damaged but the earphone was not. The earphone was placed in another earcup and met response and sensitivity requirements. Response curves appear in Appendix B, Page 78.

1.5.10 Fungus

An earphone was sent to Elite Electronic Engineering to have a fungus test performed per Method 508 of MIL-STD-810.

No fungus growth was observed. The Elite report is included in the test data in Appendix B.

1.5.11 Dust

An earphone was sent to Elite Electronic Engineering to have a dust test performed per Method 510, Procedure I of MIL-STD-810.

The before and after response curves show minimal change as a result of the exposure. These curves appear in Appendix B, Page 86.

1.5.12 Blast

A substitute blast test was performed. Twenty-two caliber blank shells were fired at close range in an enclosure to simulate the blast. A high intensity transducer was mounted next to the earphone and the output connected to a B & K Model 2606 Audio Voltmeter, with the input set to Peak and Hold to record the peak pressure level. Thirty shots were fired providing a peak pressure of 9.5 SPL, the same pressure specified for the SK-N-864 Simulated Gun Blast Test.

The earphone was tested and showed no degradation in performance as a result of the blast test. The before and after curves appear in Appendix B, Page 87.

APPENDIX A

The G.E. Basic Program

```
READY
NEW EARPHONE

READY
1000 AC ANALYSIS
1010 B1 N(0,1),C=1.15E-4
1020 B2 N(1,2),L=1E-5
1030 B3 N(2,0),C=9.8E-7
1040 B4 N(2,3),C=4.36E-8,E=0.14
1050 B5 N(3,4),L=.14
1060 B6 N(4,5),R=500
1070 B7 N(5,0),C=1.13E-6
1080 B8 N(5,6),R=12
1090 B9 N(6,7),L=6.9E-4
1100 B10 N(7,0),C=2,1
1100 B10 N(7,0),C=2.1E-6
1110 FREQUENCY=10
1120 BINARY,BV
1130 PLOT,(DB),BV(1)
1140 MODIFY
1150 FREQUENCY=20(1.259)1E4
1160 EXECUTE
SAVE
```

Example of typical program input to ECAP.

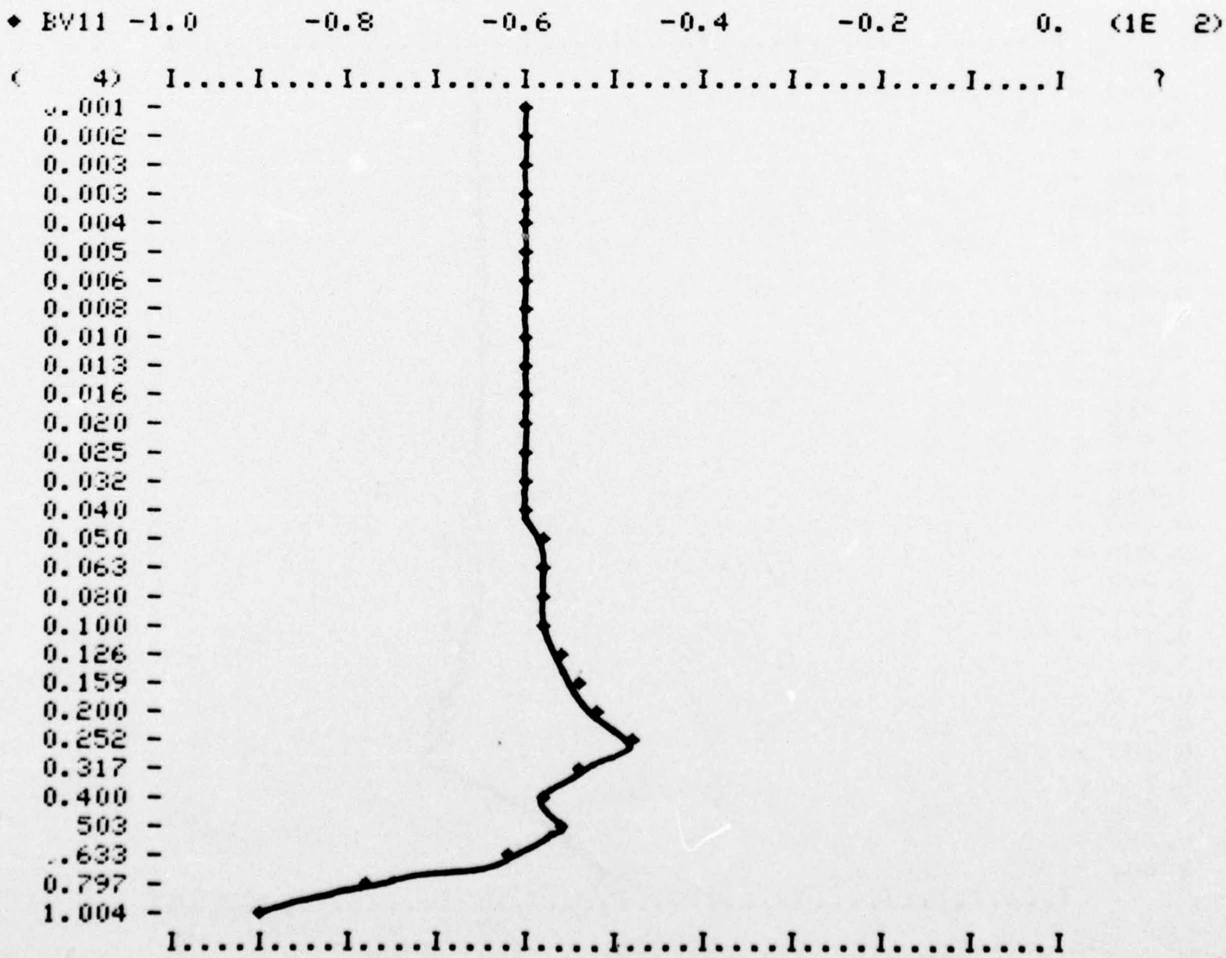
```
ECAP%%       07:49EST     10/13/76

GENERAL ELECTRIC ECAP - 4/11/75

INPUT FILE NAME ?EARPHONE

OUTPUT FILE NAME?GRAPH

        AC ANALYSIS
B1      N(0,1),L=0.093,E=0.14
B2      N(1,2),R=500
B3      N(2,3),C=4.36E-8
B4      N(3,4),R=12.66
B5      N(4,5),L=1.38E-3
B6      N(5,6),R=47.5
B7      N(6,7),L=2E-3
B8      N(5,7),C=2.1E-6
B9      N(7,8),L=1E-3
B10     N(8,9),R=1.5
B11     N(9,0),C=4.62E-6
B12     N(7,0),C=9.8E-7
B13     N(3,7),C=1.13E-6
        FREQUENCY =10
        BINARY,BV
```



COMMAND?END

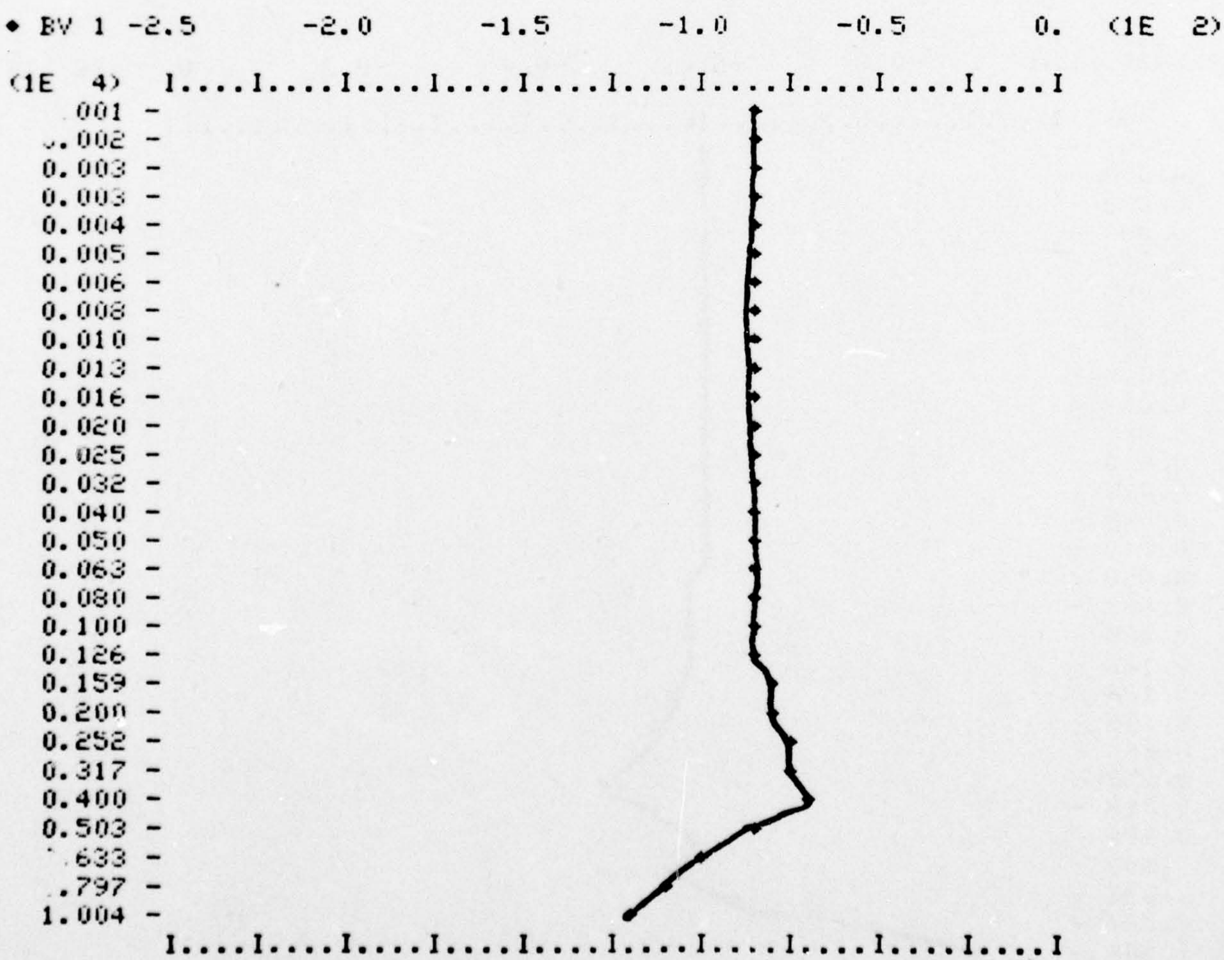
6cc Model H-143 earphone

```
GENERAL ELECTRIC ECAP - 4/11/75

INPUT FILE NAME ?EARCUP

OU.PUT FILE NAME?GRAPH

        AC ANALYSIS
B1      N(0,1),C=1.15E-4
B2      N(1,2),L=1.5E-3
B3      N(2,3),R=1.5
B4      N(3,4),C=4.36E-8,E=0.14
B5      N(4,5),L=.08
B6      N(5,6),R=500
B7      N(6,7),R=1
B8      N(7,8),L=1.38E-3
B9      N(8,0),C=2.1E-6
B10     N(6,0),C=1.13E-6
B11     N(3,0),C=9.8E-7
B12     N(8,9),L=2E-3
B13     N(9,1),R=1E6
        FREQUENCY=10
        BINARY,BV
```



150 cc Model H-143 earphone rear vent closed.

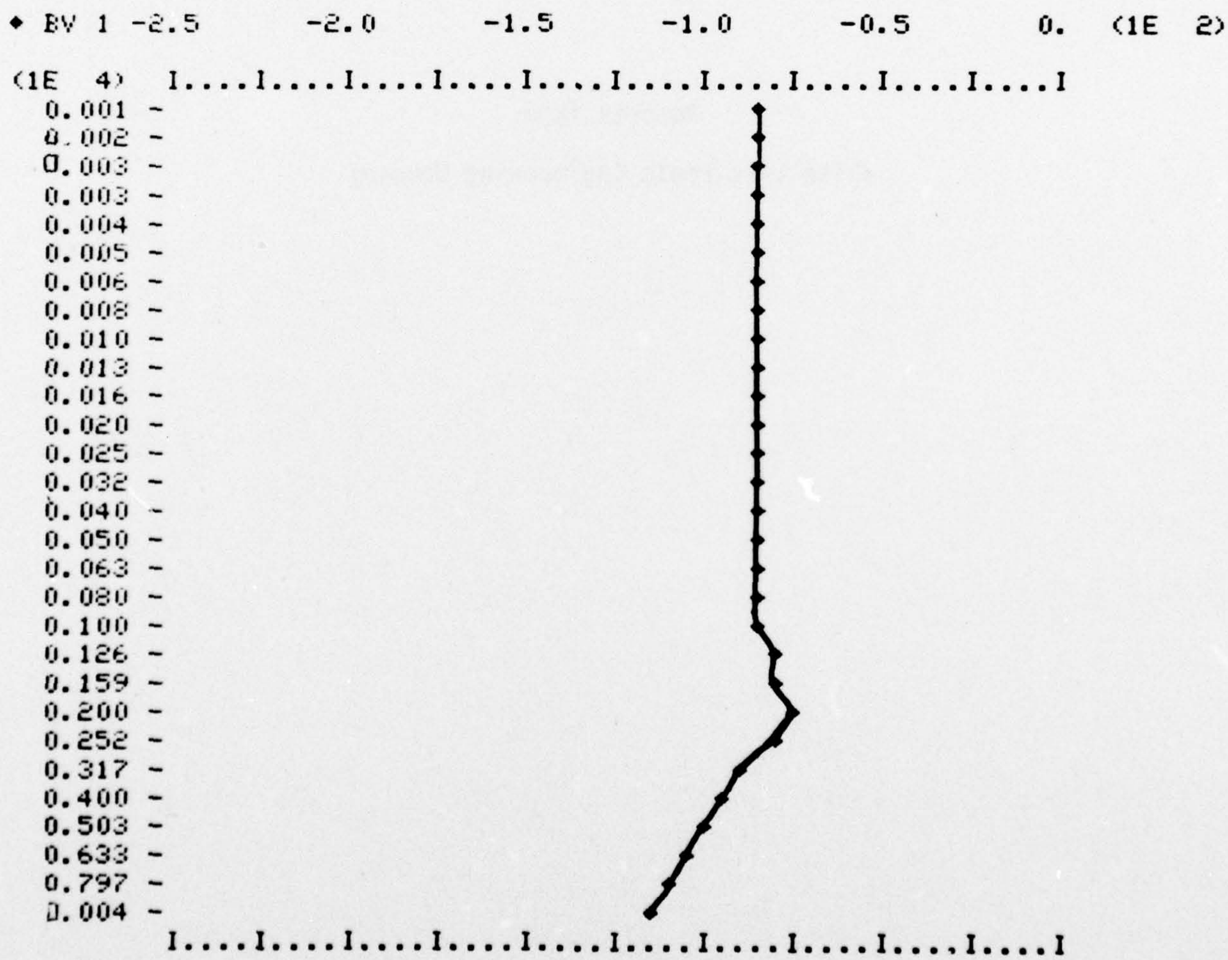
COMMAND?END

```
GENERAL ELECTRIC ECAP - 4/11/75

INPUT FILE NAME ?EARPHONE

OUTPUT FILE NAME?GRAPH

       AC ANALYSIS
B1     N(0,1),C=1.15E-4
B2     N(1,2),L=1E-5
B3     N(2,0),C=9.8E-7
B4     N(2,3),C=4.36E-8,E=0.14
B5     N(3,4),L=.14
B6     N(4,5),R=500
B7     N(5,0),C=1.13E-6
B8     N(5,6),R=12
B9     N(6,7),L=6.9E-4
B10    N(7,0),C=2.1E-6
       FREQUENCY=10
       BINARY,BV
```



150 cc Model 986 earphone

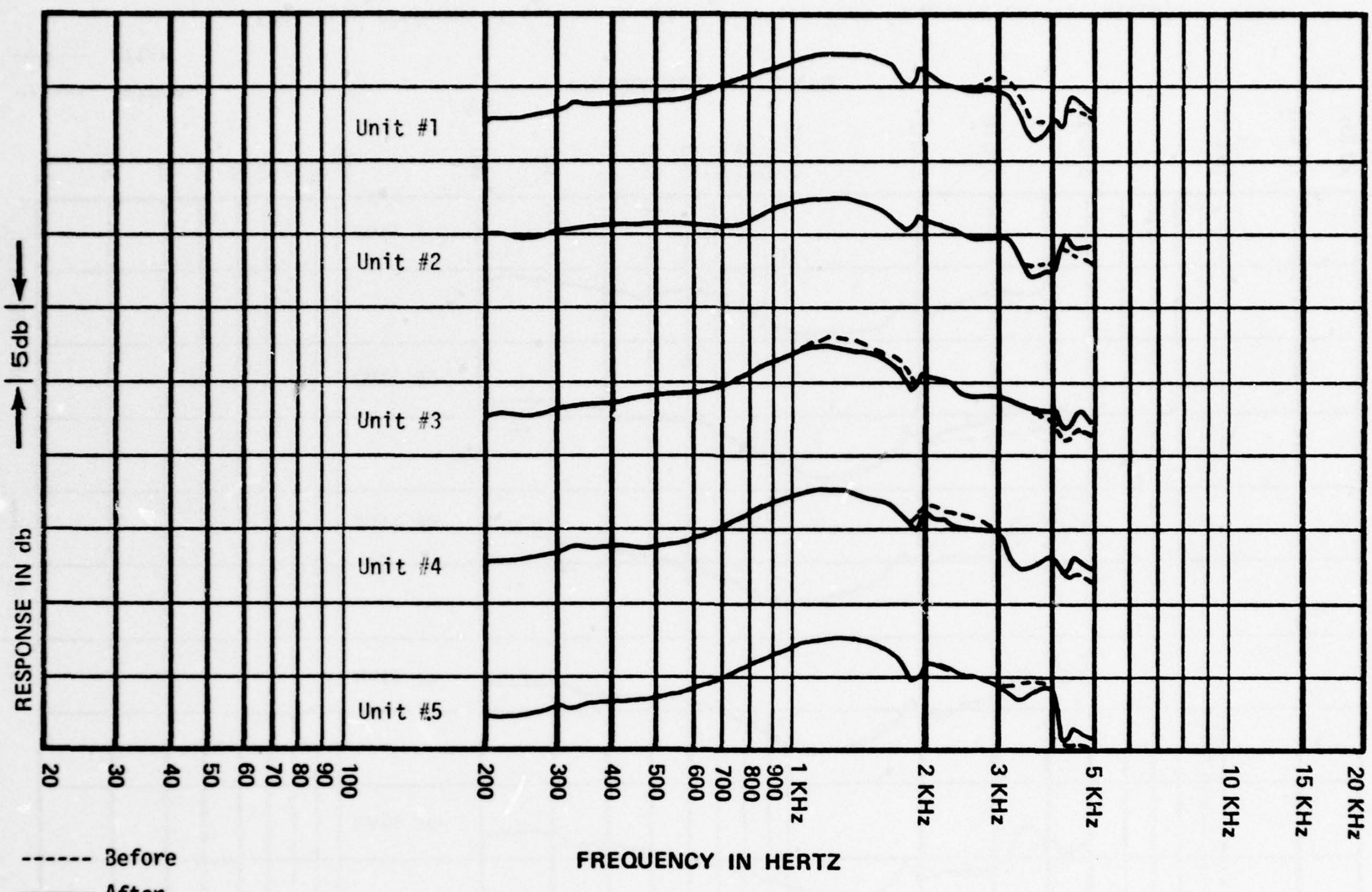
```
COMMAND?END
```

APPENDIX B

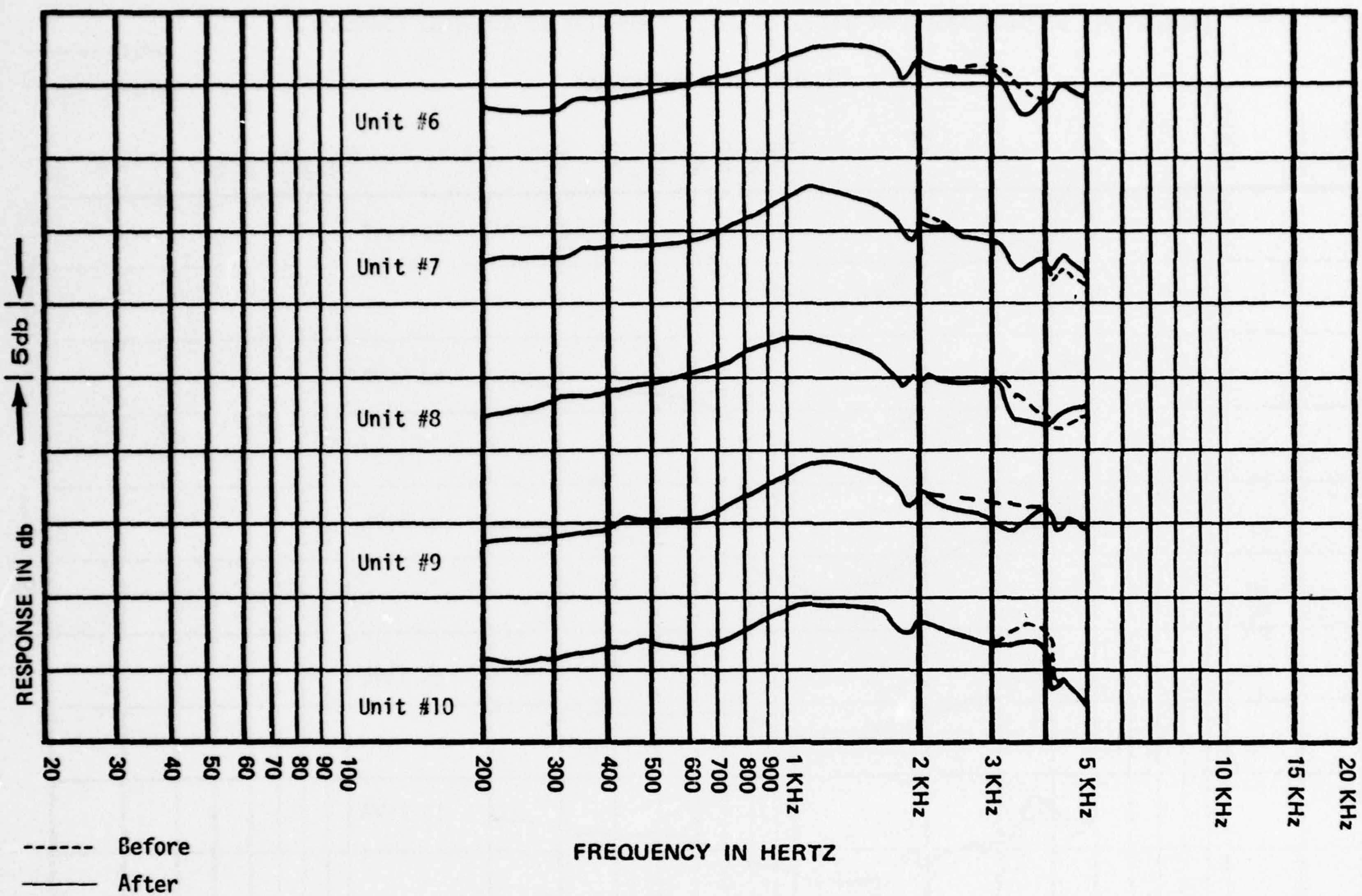
Curves

Reports from

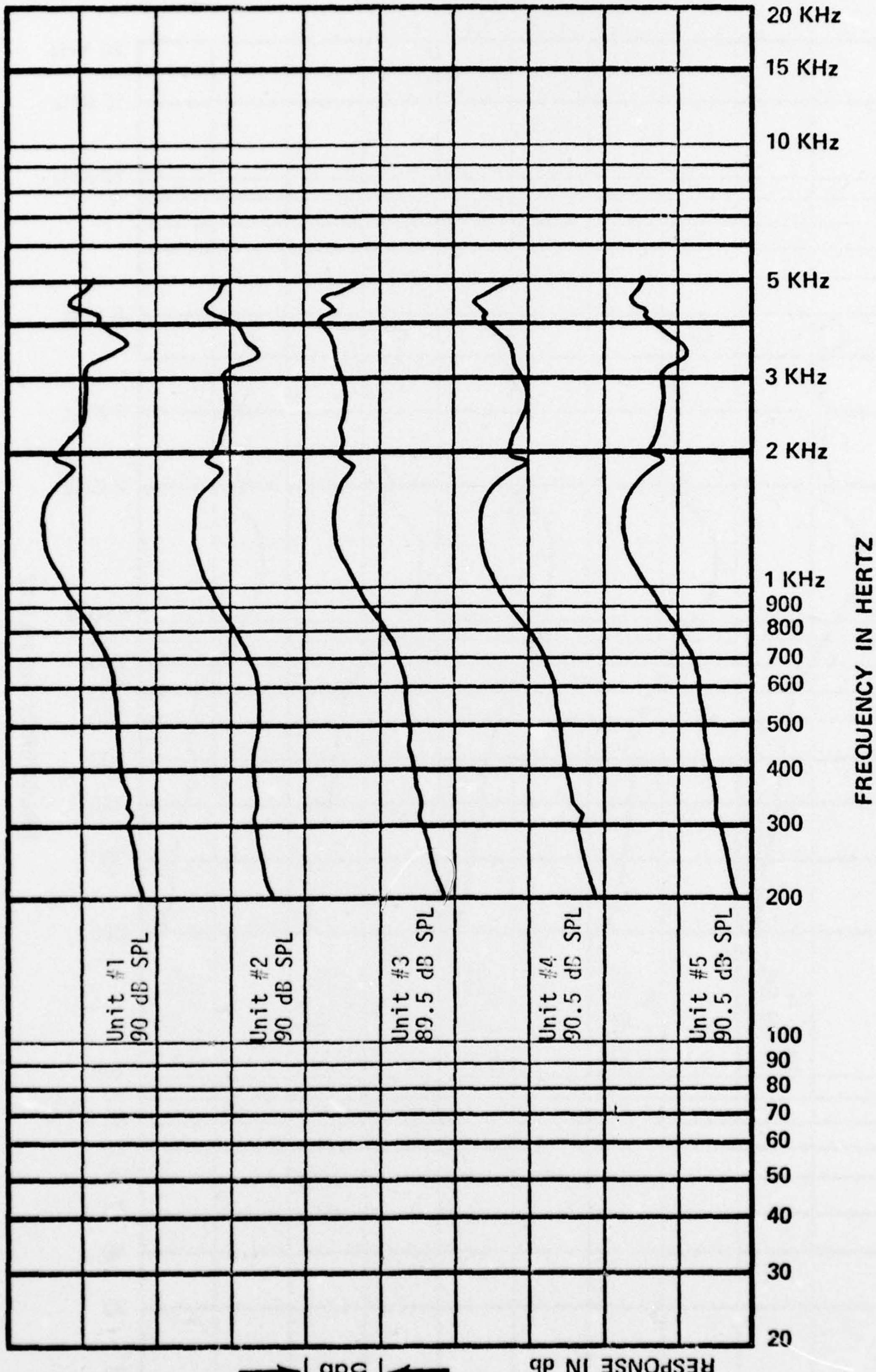
Elite Electronic Engineering Company



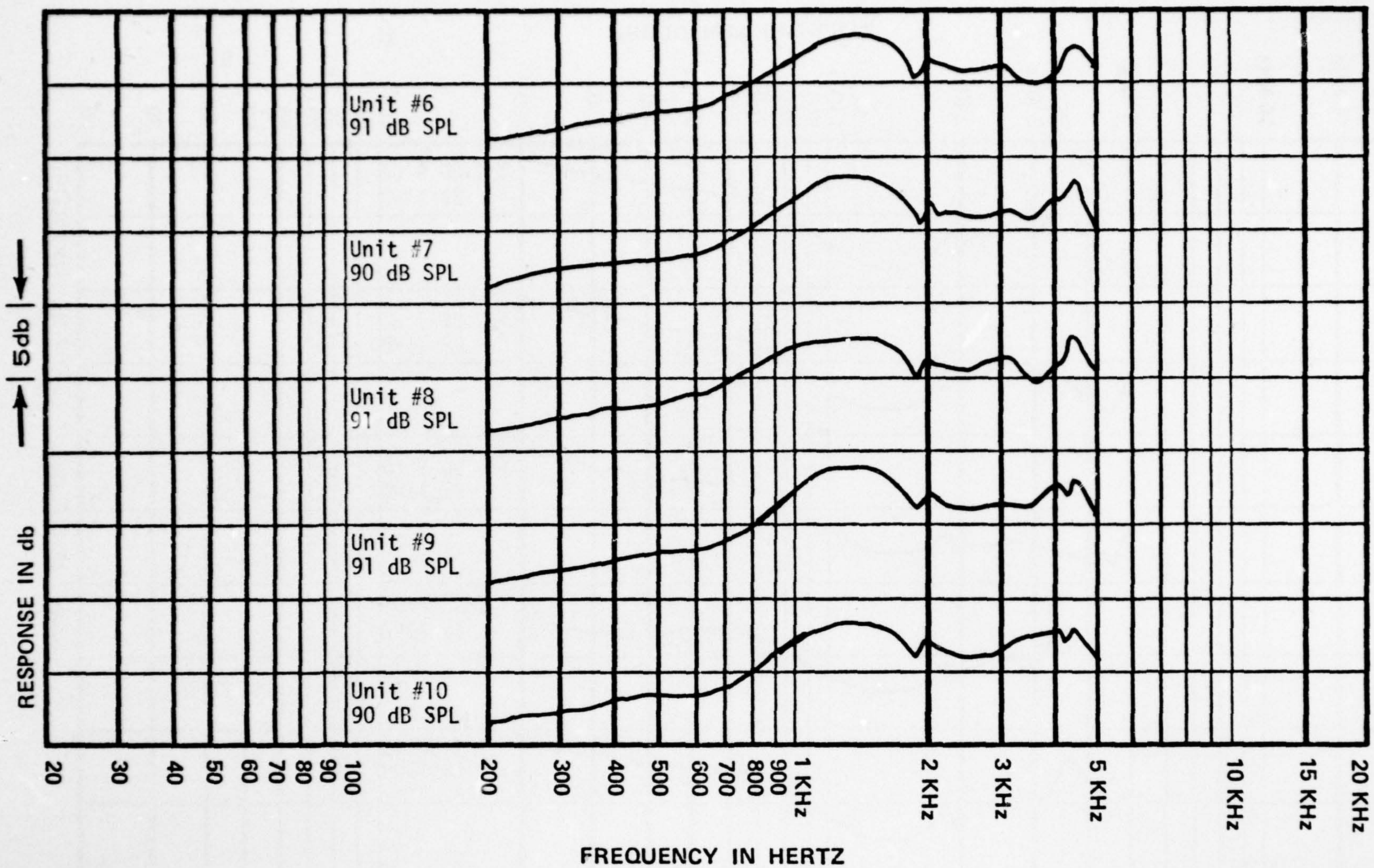
Frequency response of earphones after overload test (measured on flat plate)



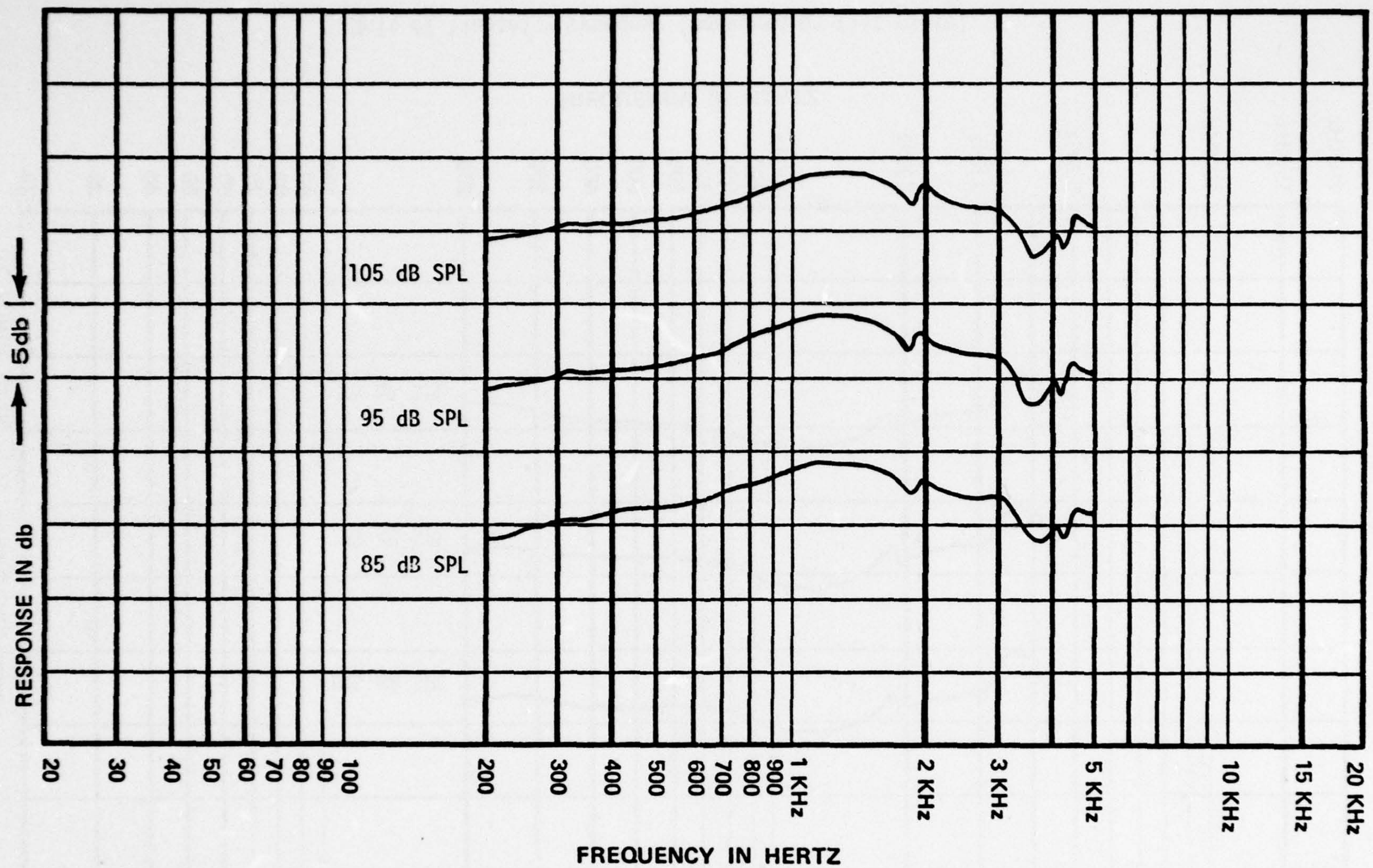
Frequency response of earphones after overload test (measured on flat plate).



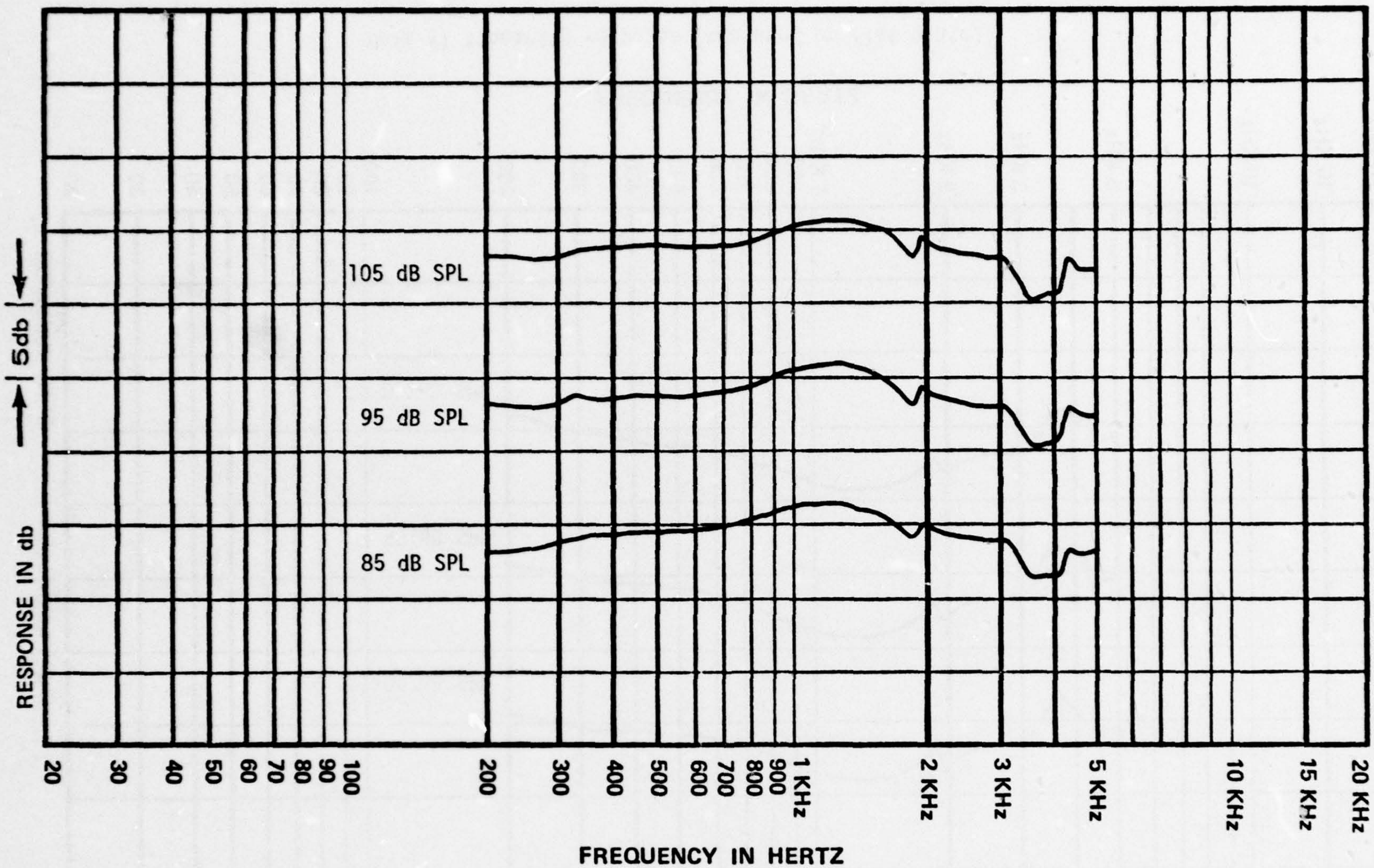
FREQUENCY IN HERTZ
20 KHz
15 KHz
10 KHz
5 KHz
3 KHz
2 KHz
1 KHz
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
Unit #1 90 dB SPL
Unit #2 90 dB SPL
Unit #3 89.5 dB SPL
Unit #4 90.5 dB SPL
Unit #5 90.5 dB SPL
RESPONSE IN db
5db



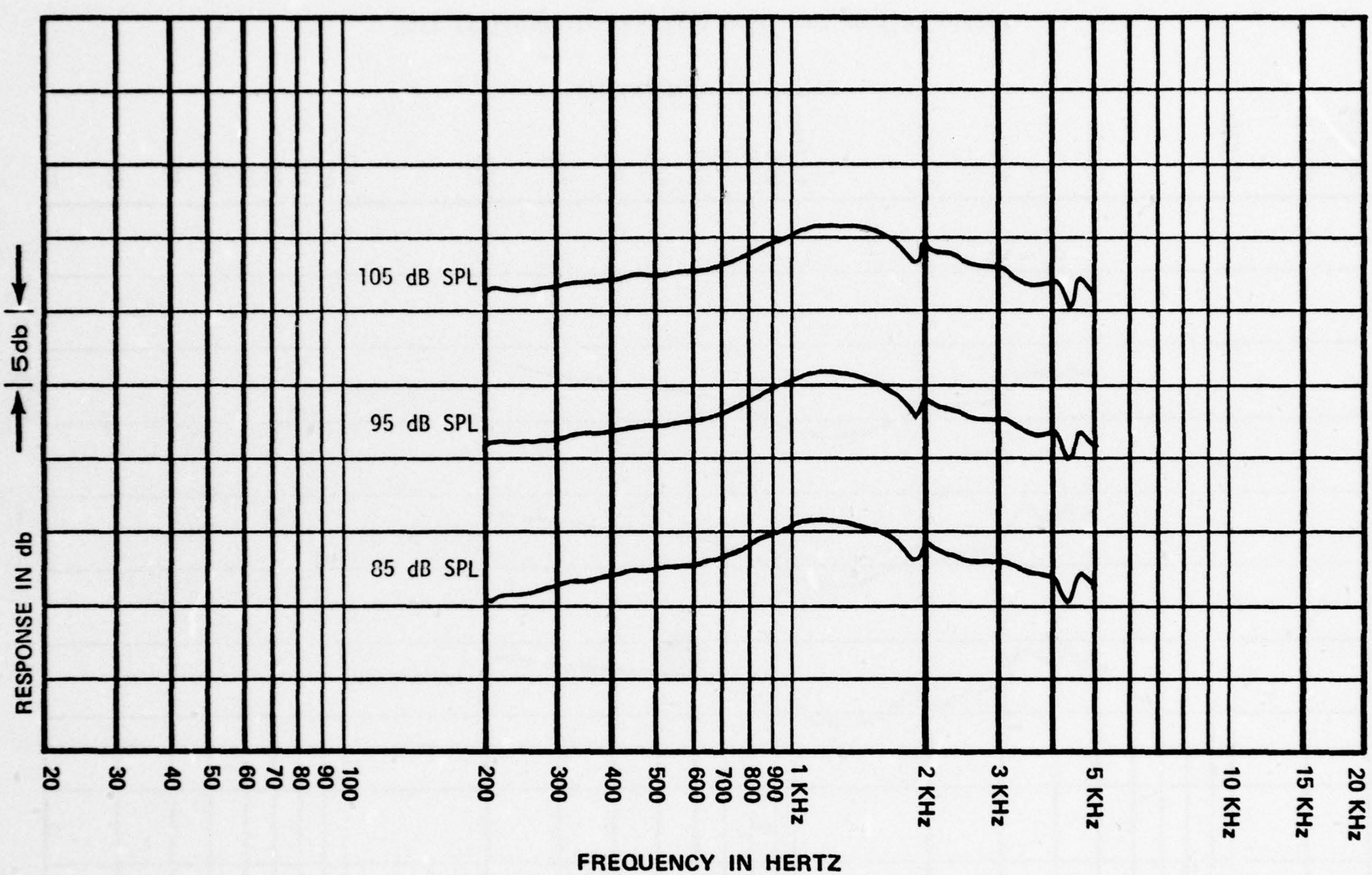
Sensitivity with 1 mW at 1 kHz and frequency response of earphones.



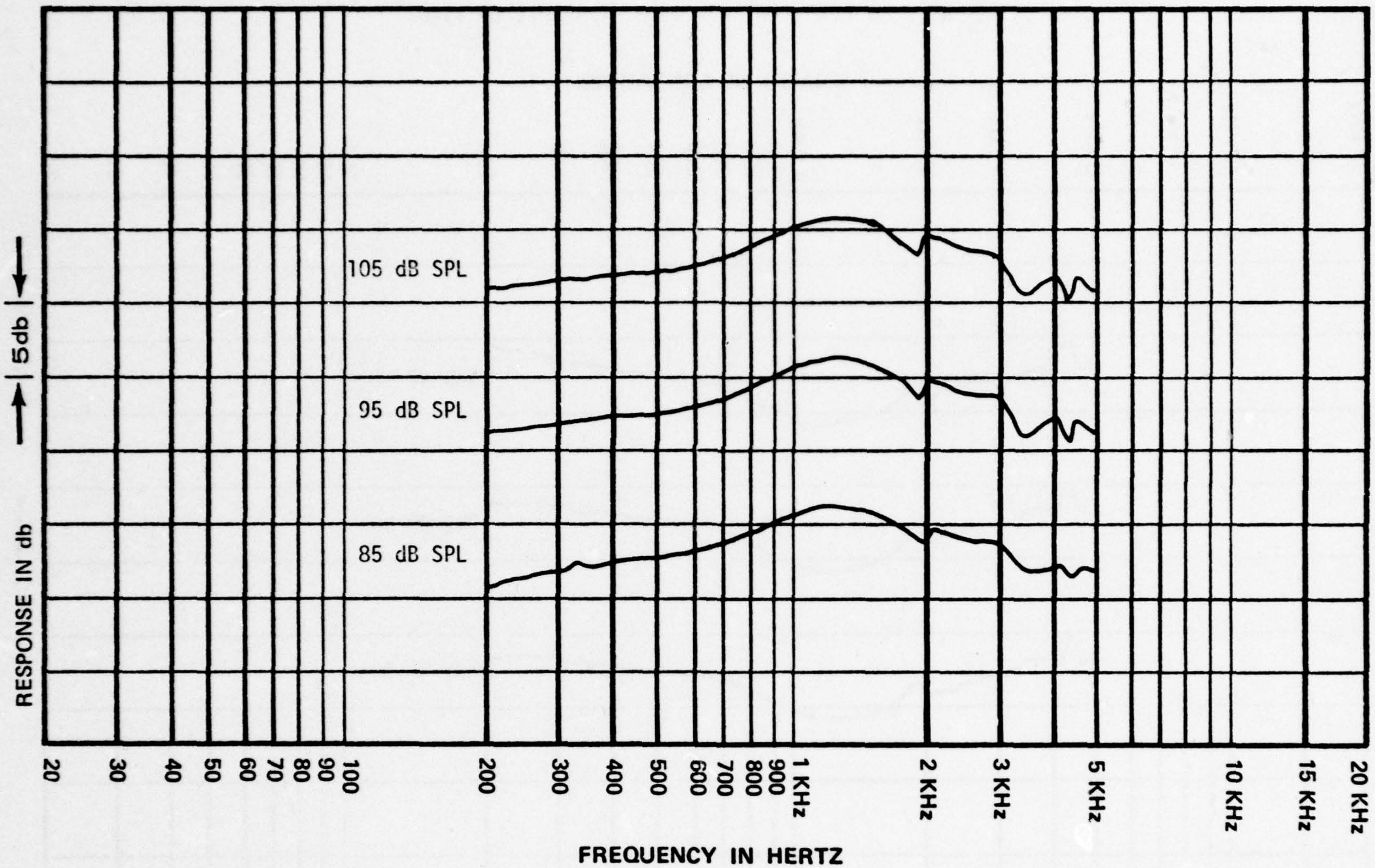
Unit #1 linearity response (measured on flat plate).



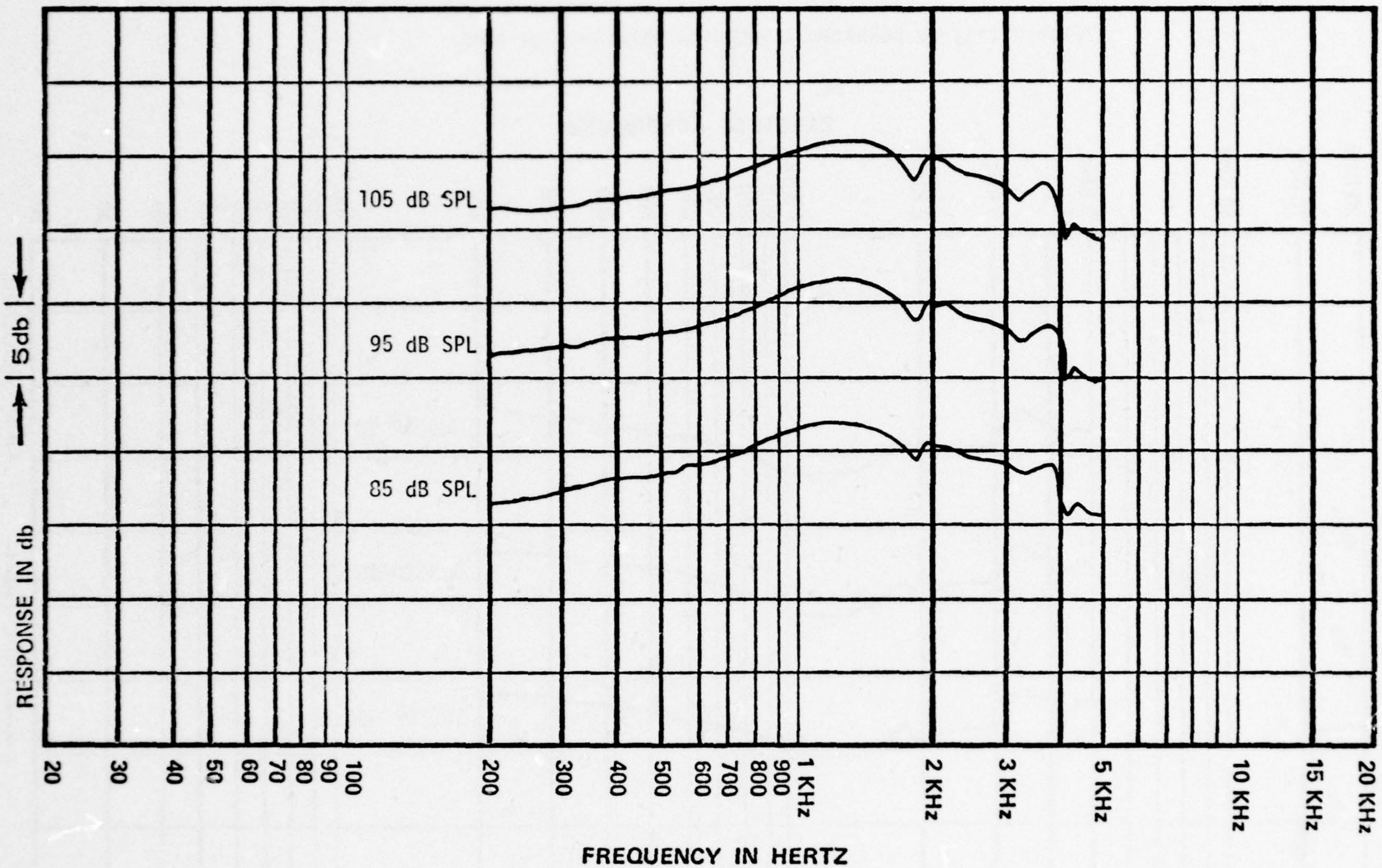
Unit #2 linearity response (measured on flat plate).



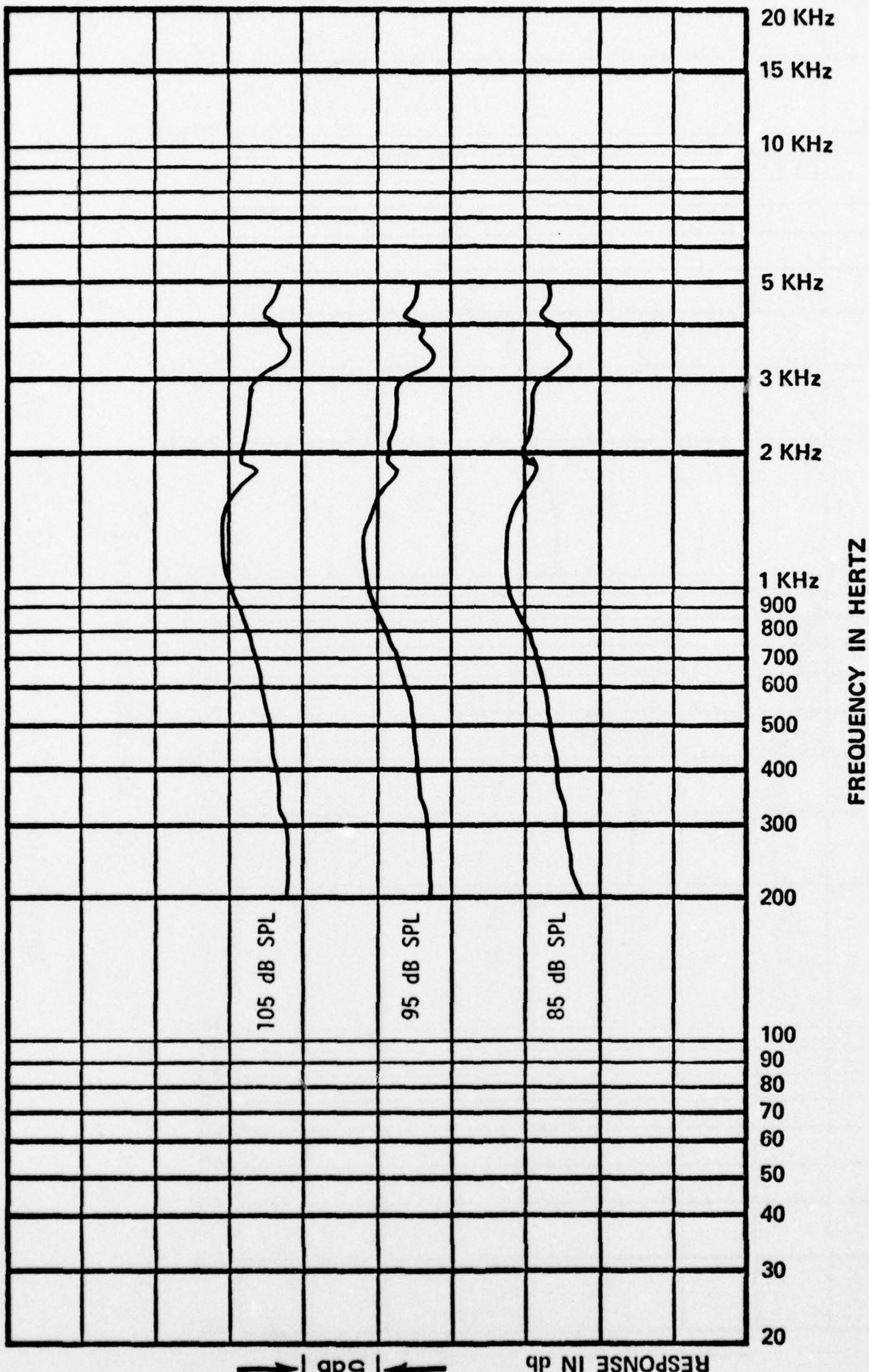
Unit #3 linearity response (measured on flat plate).



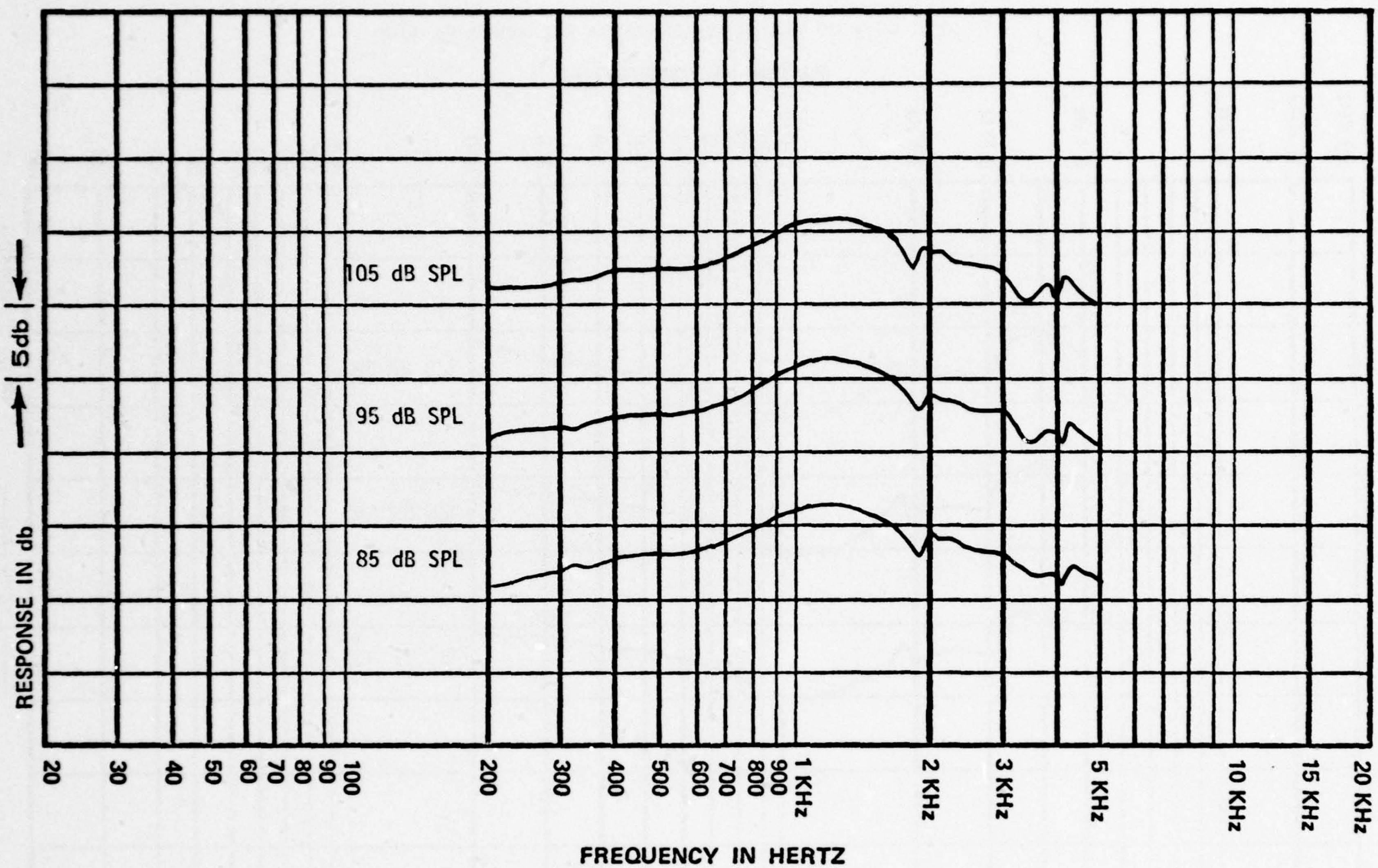
Unit #4 linearity response (measured on flat plate).



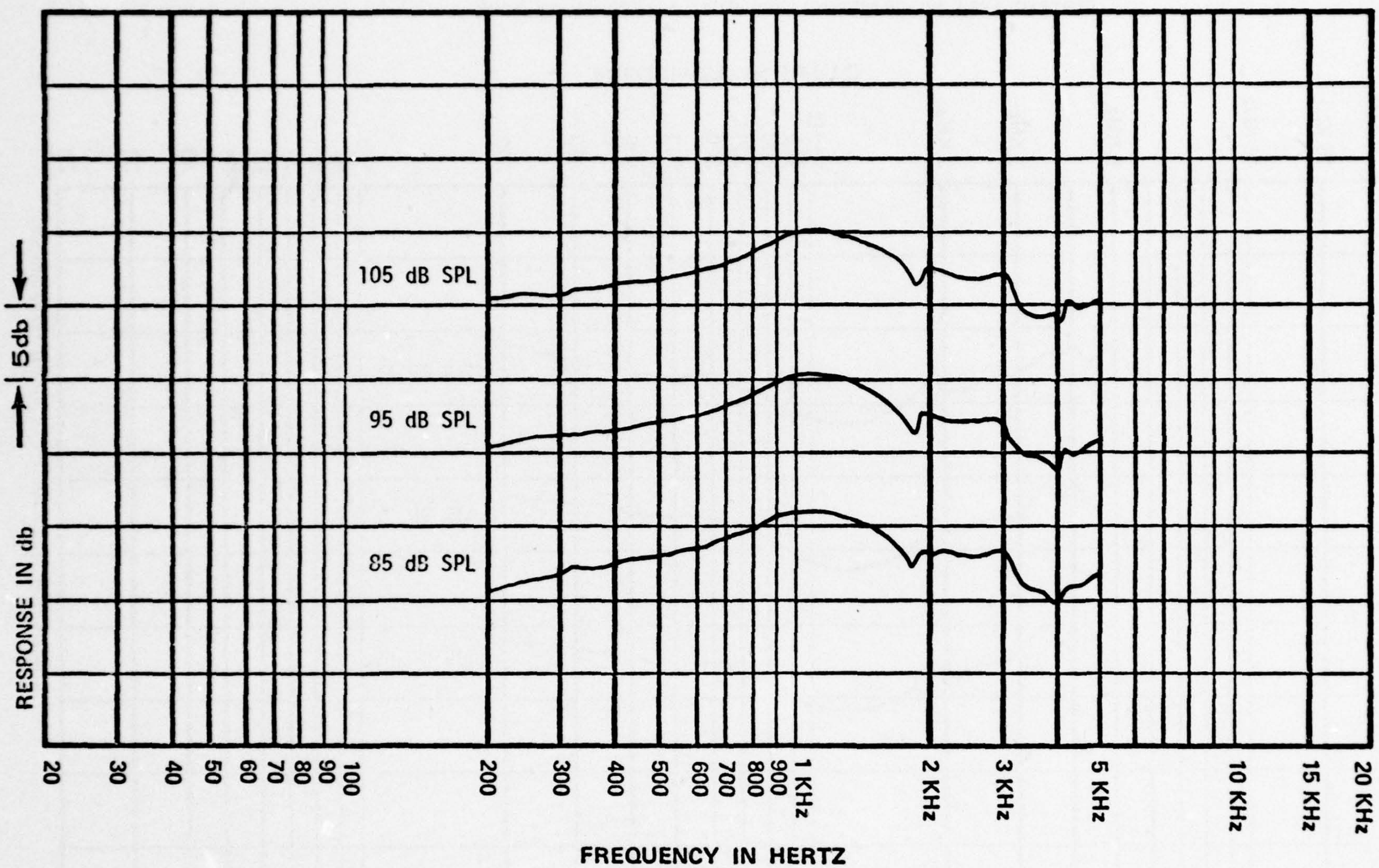
Unit #5 linearity response (measured on flat plate).



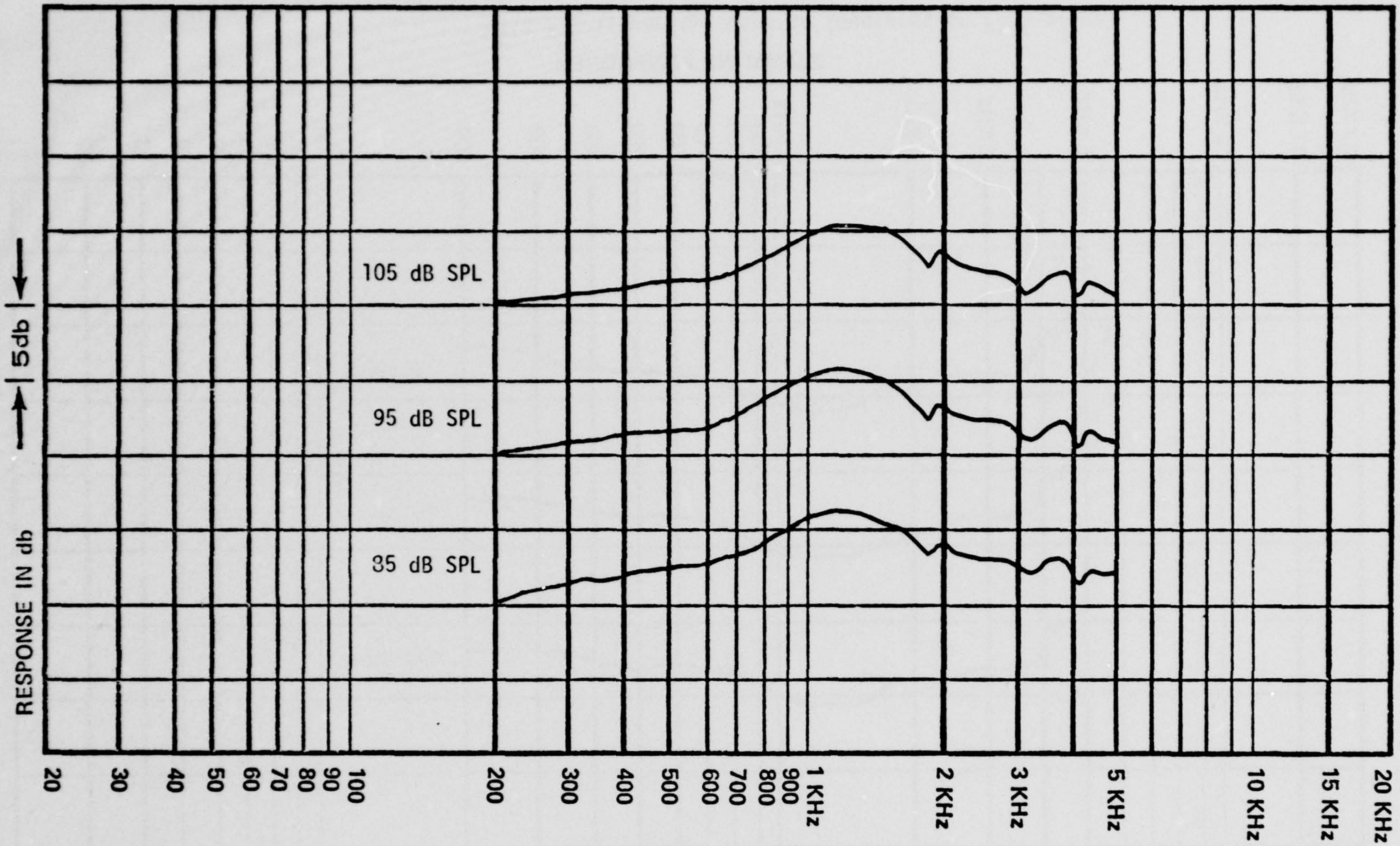
Unit #6 linearity response (measured on flat plate).



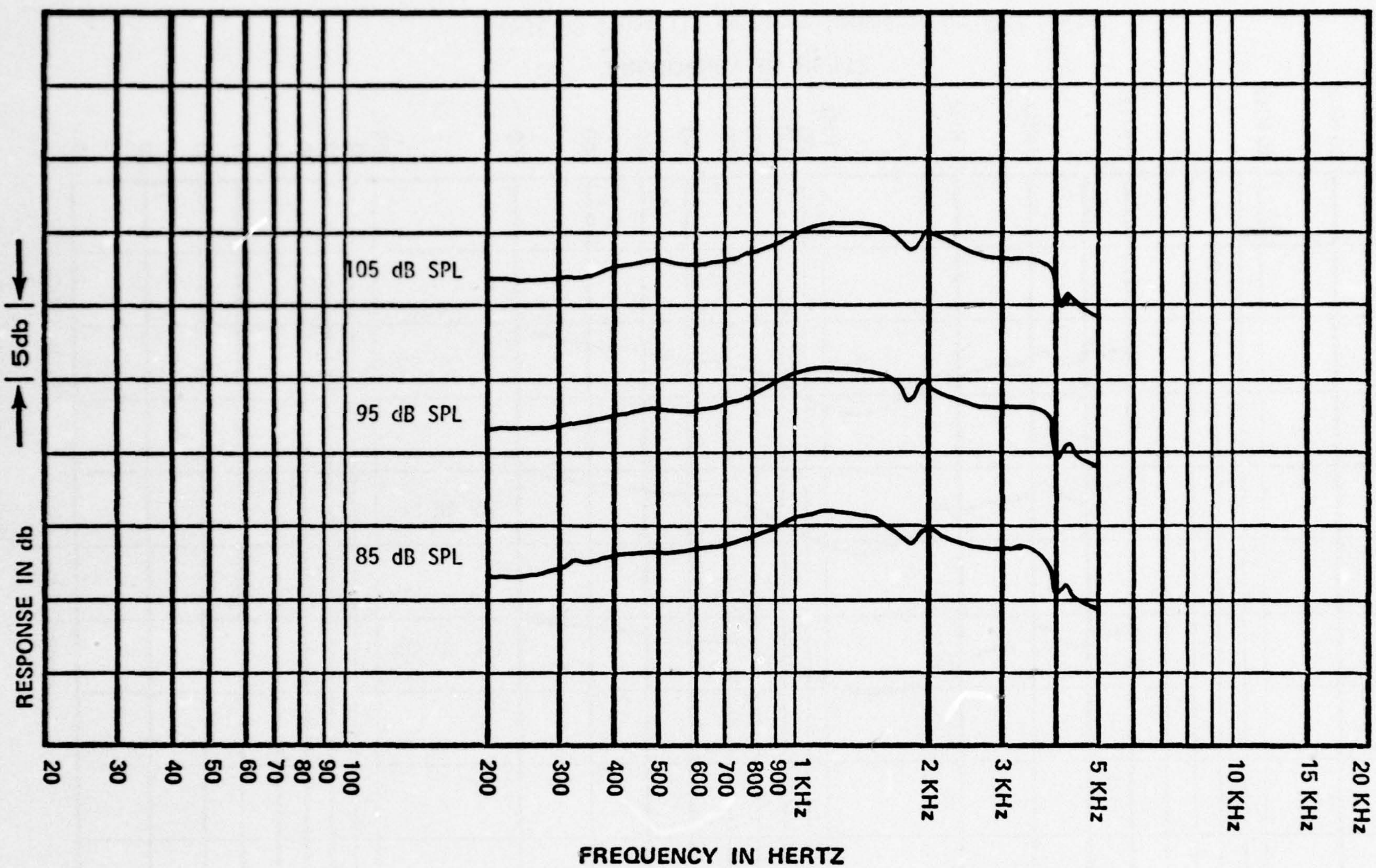
Unit #7 linearity response (measured on flat plate).



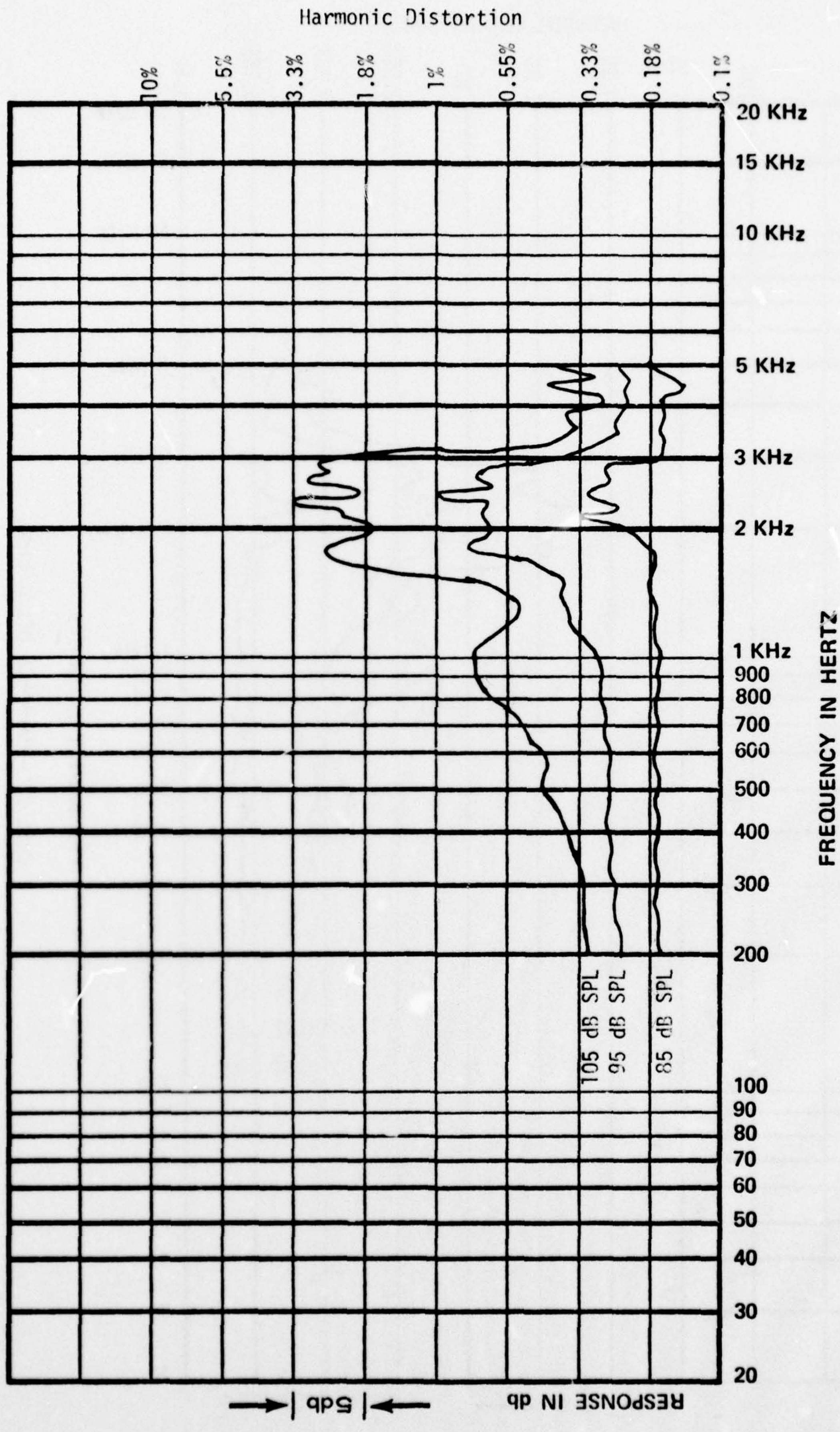
Unit #8 linearity response (measured on flat plate).



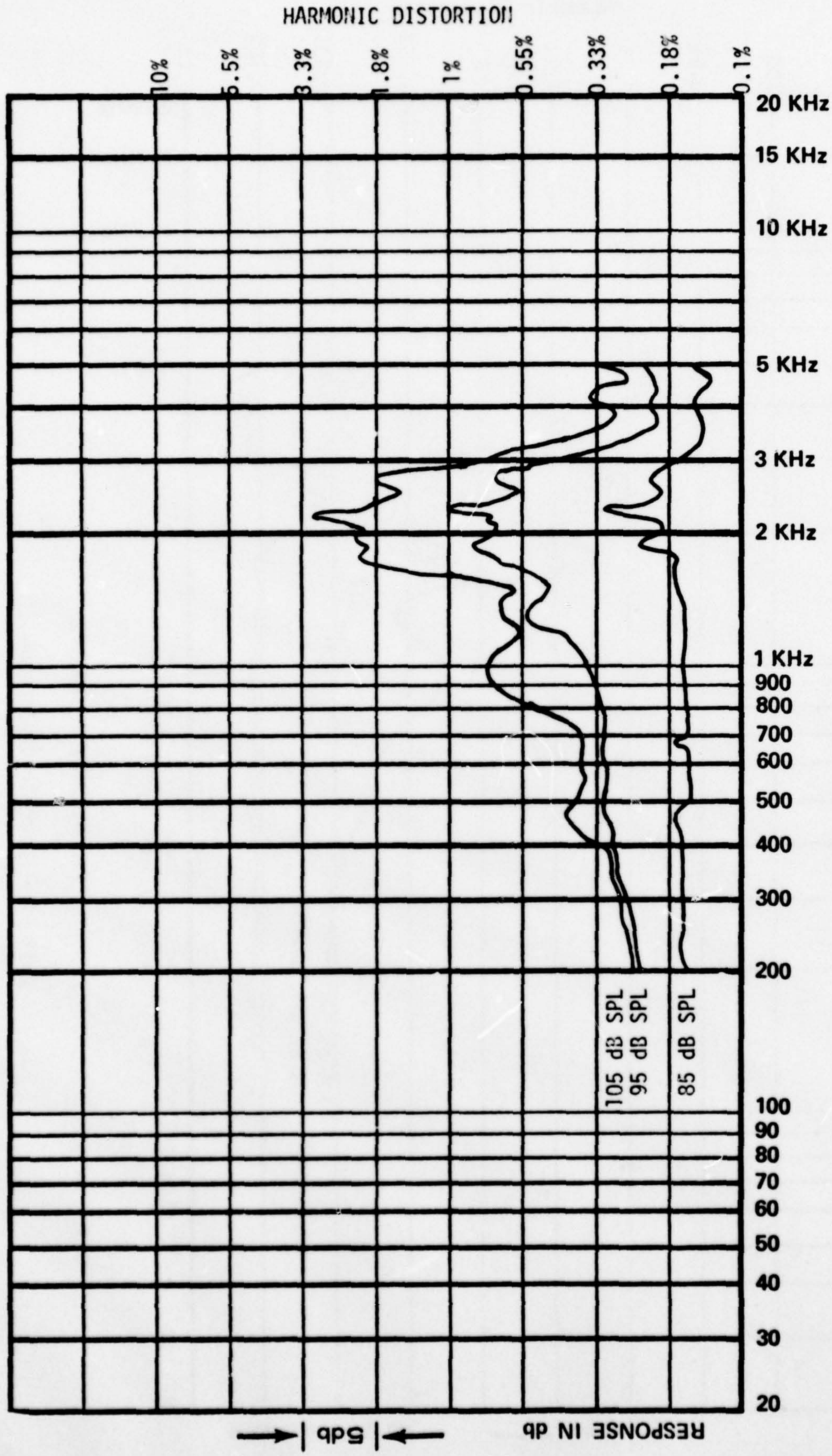
Unit #9 linearity response (measured on flat plate).



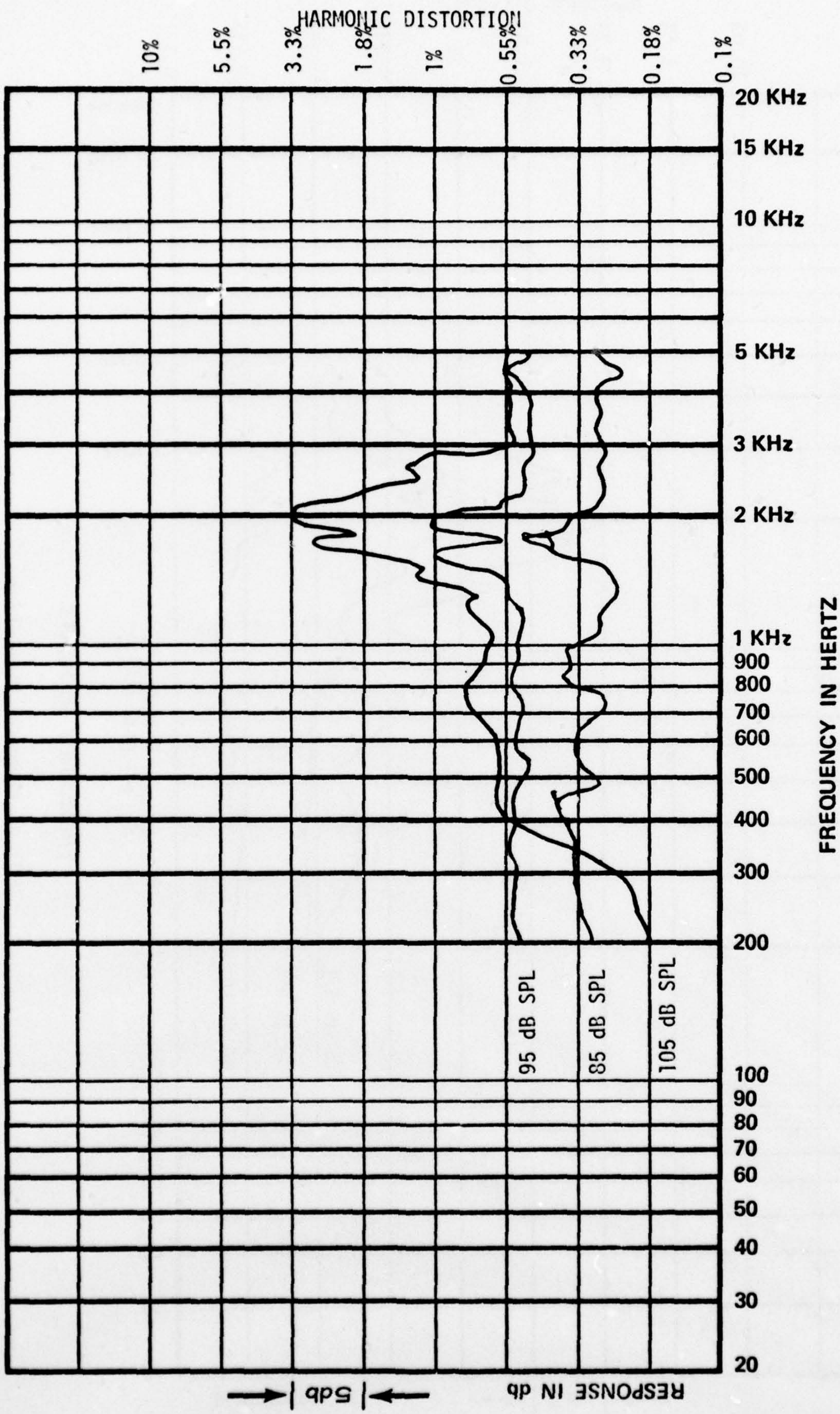
Unit #10 linearity response (measured on flat plate).



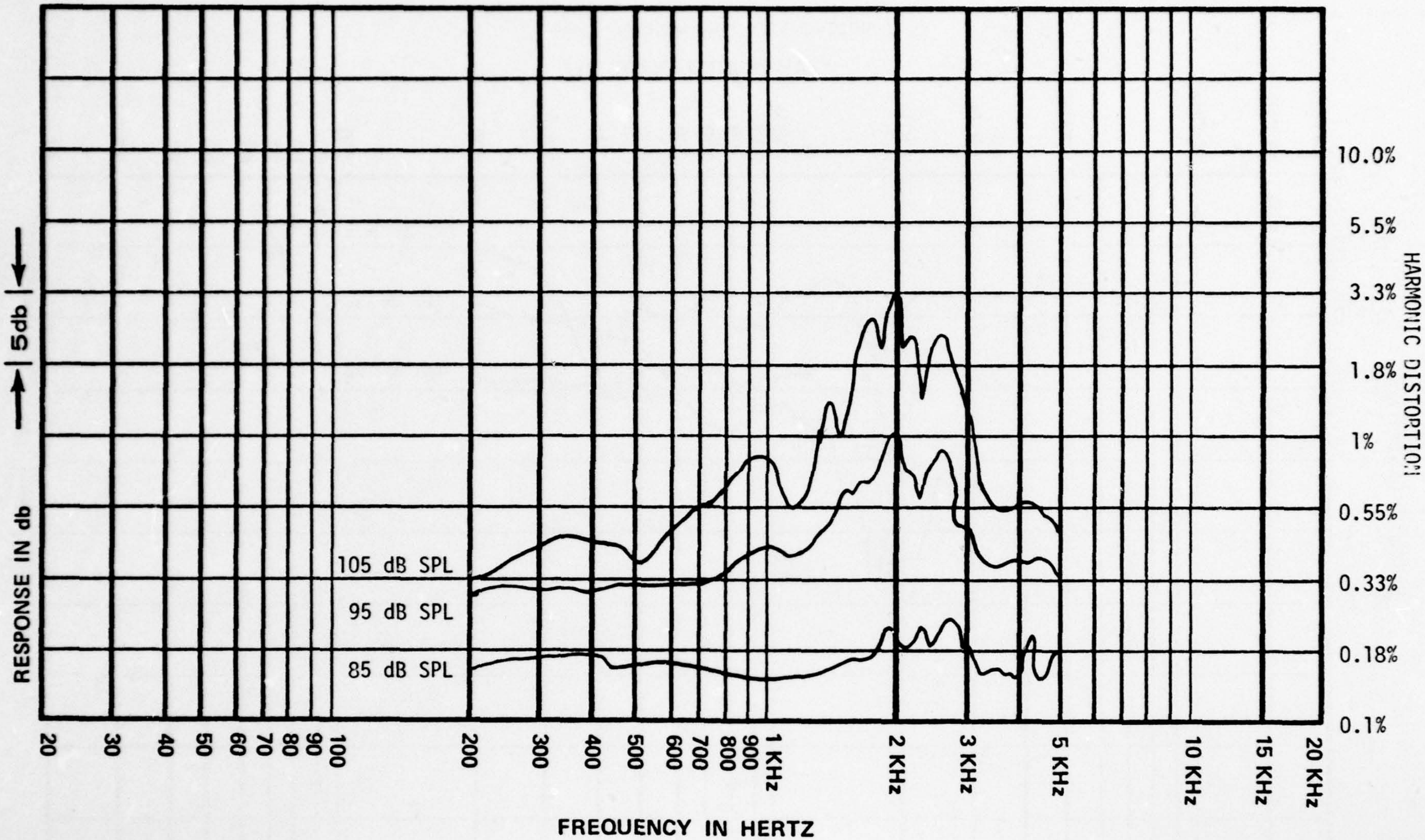
Unit #1 - Harmonic Distortion



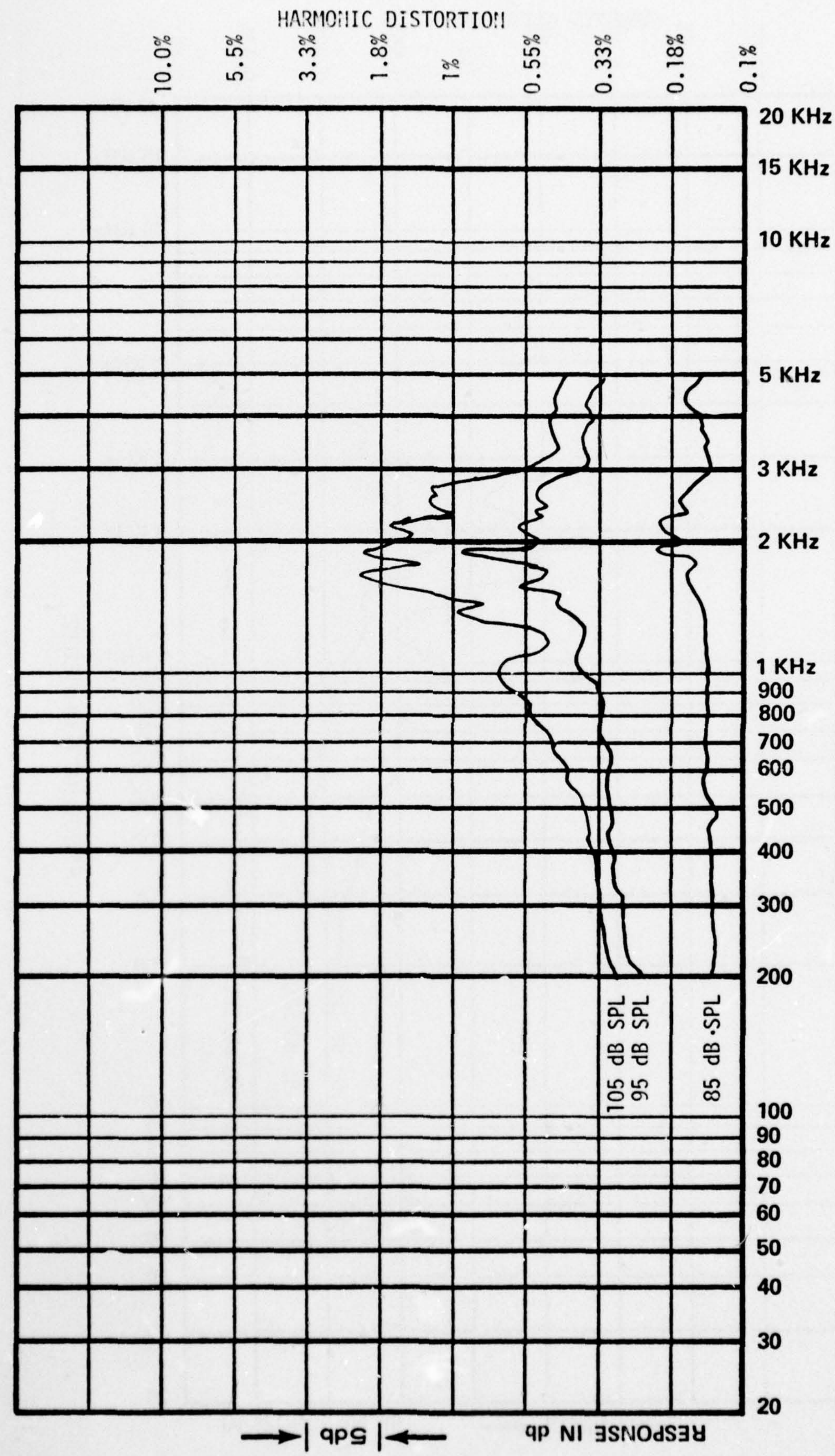
Unit #2 - Harmonic Distortion



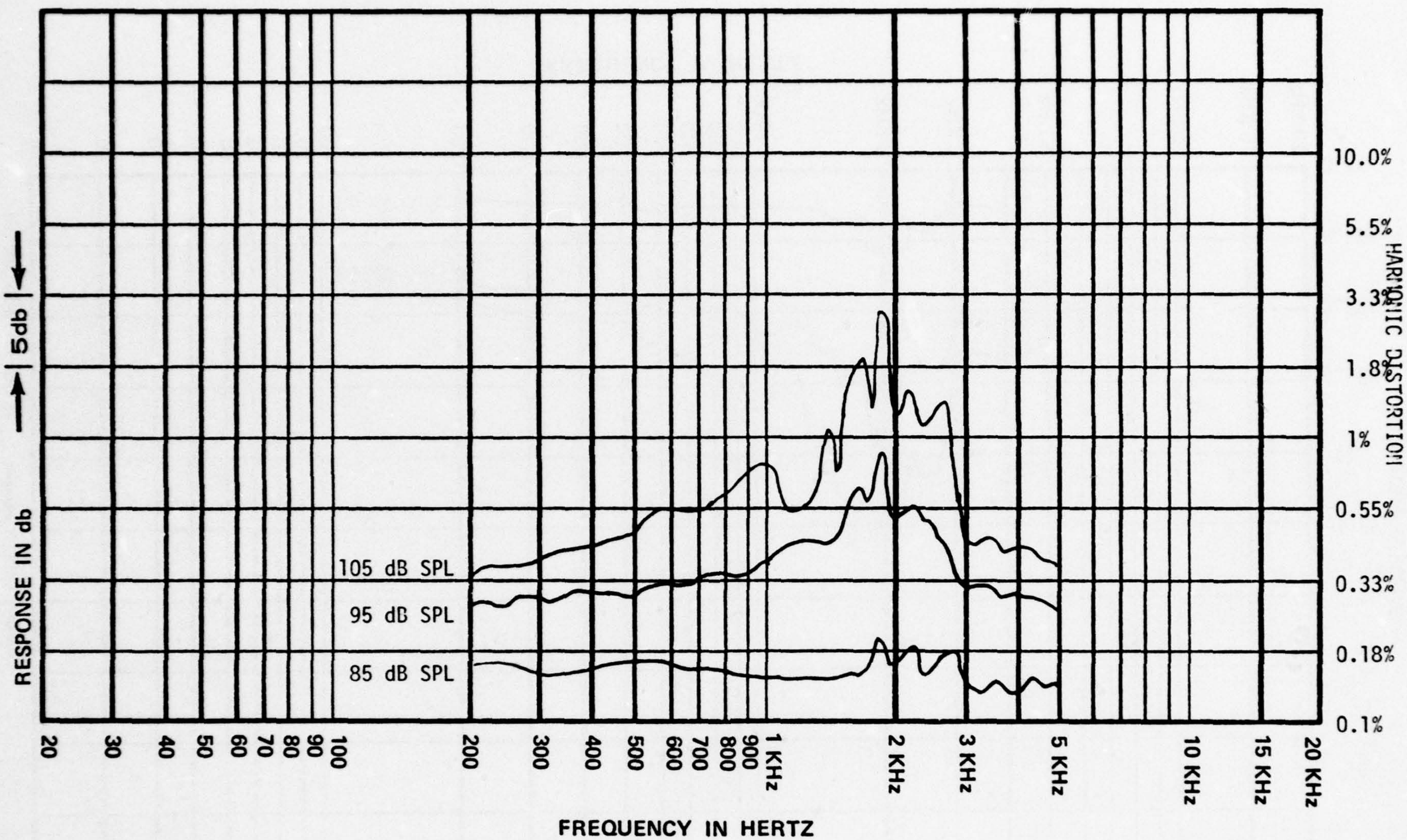
Unit #3-Harmonic Distortion



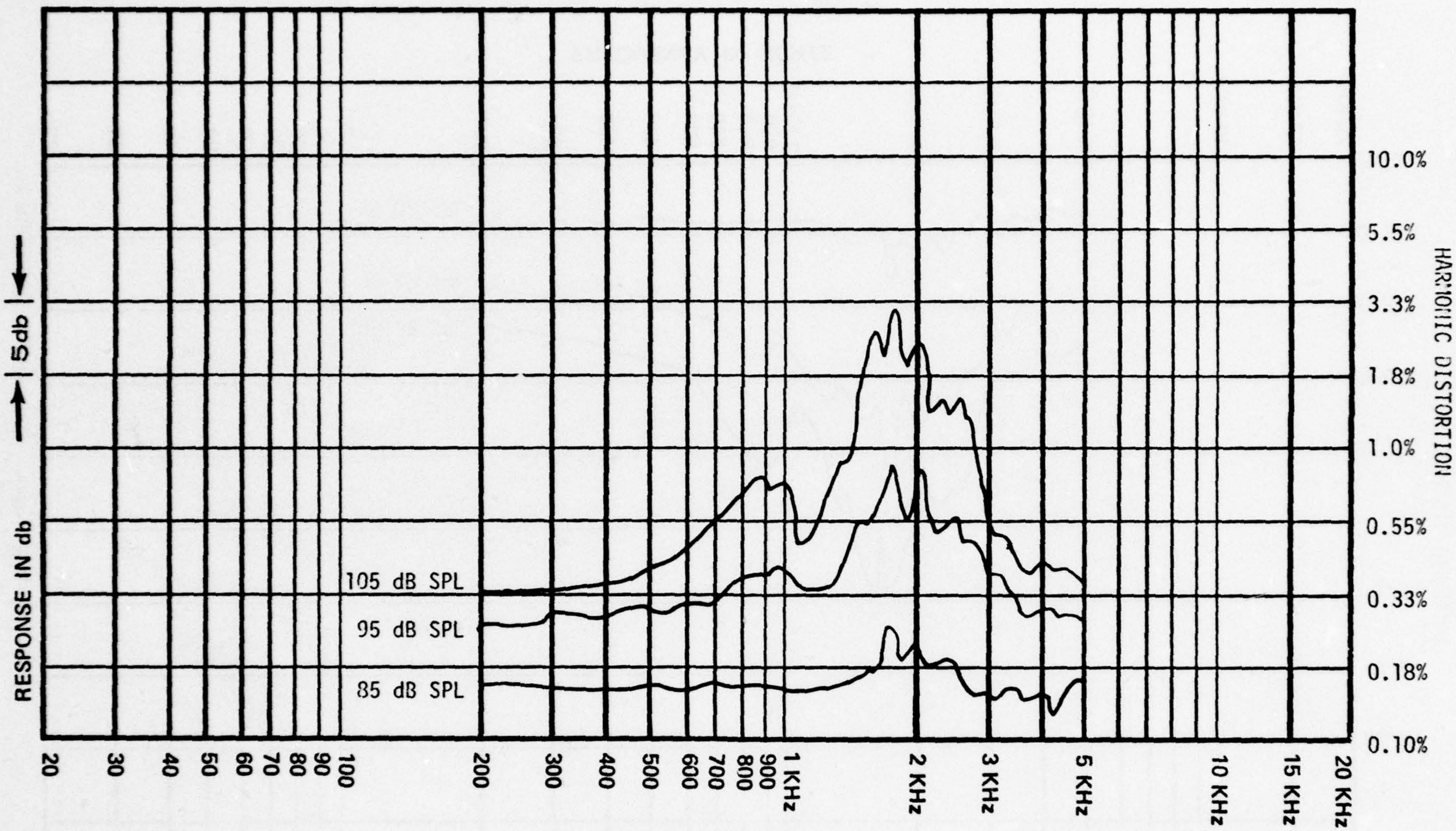
Unit #4-Harmonic Distortion



Unit #5 - Harmonic Distortion

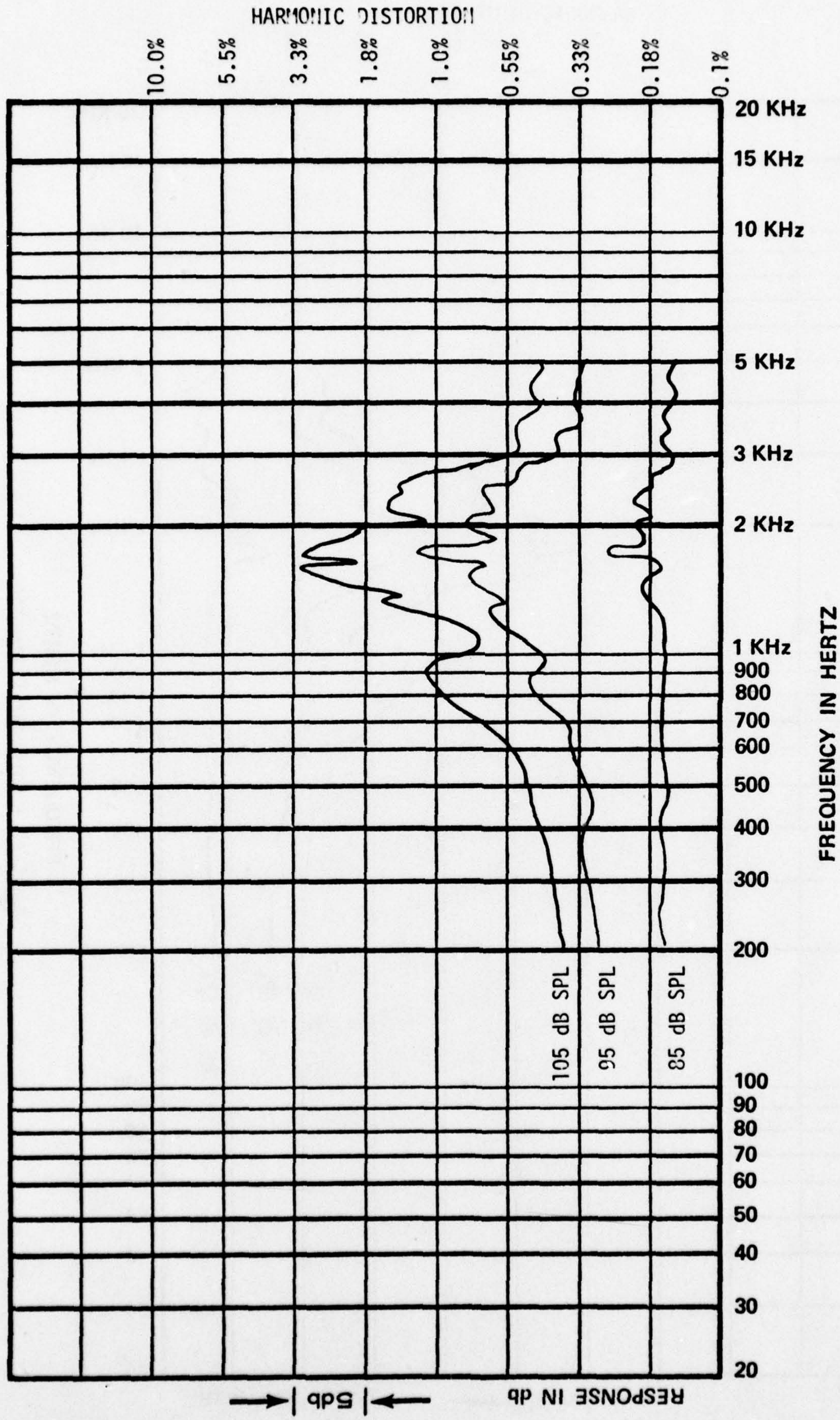


Unit #6 - Harmonic Distortion

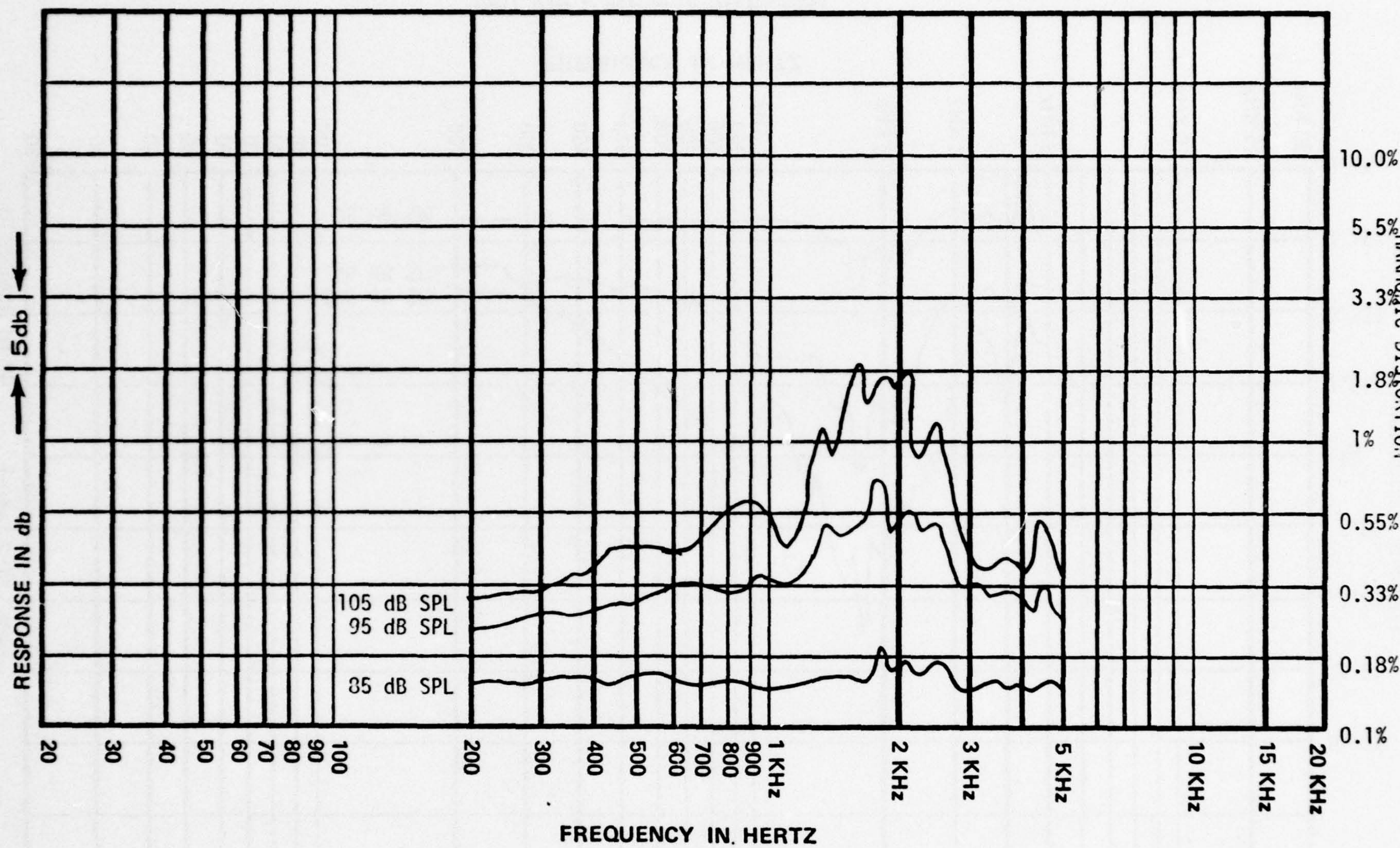


FREQUENCY IN HERTZ

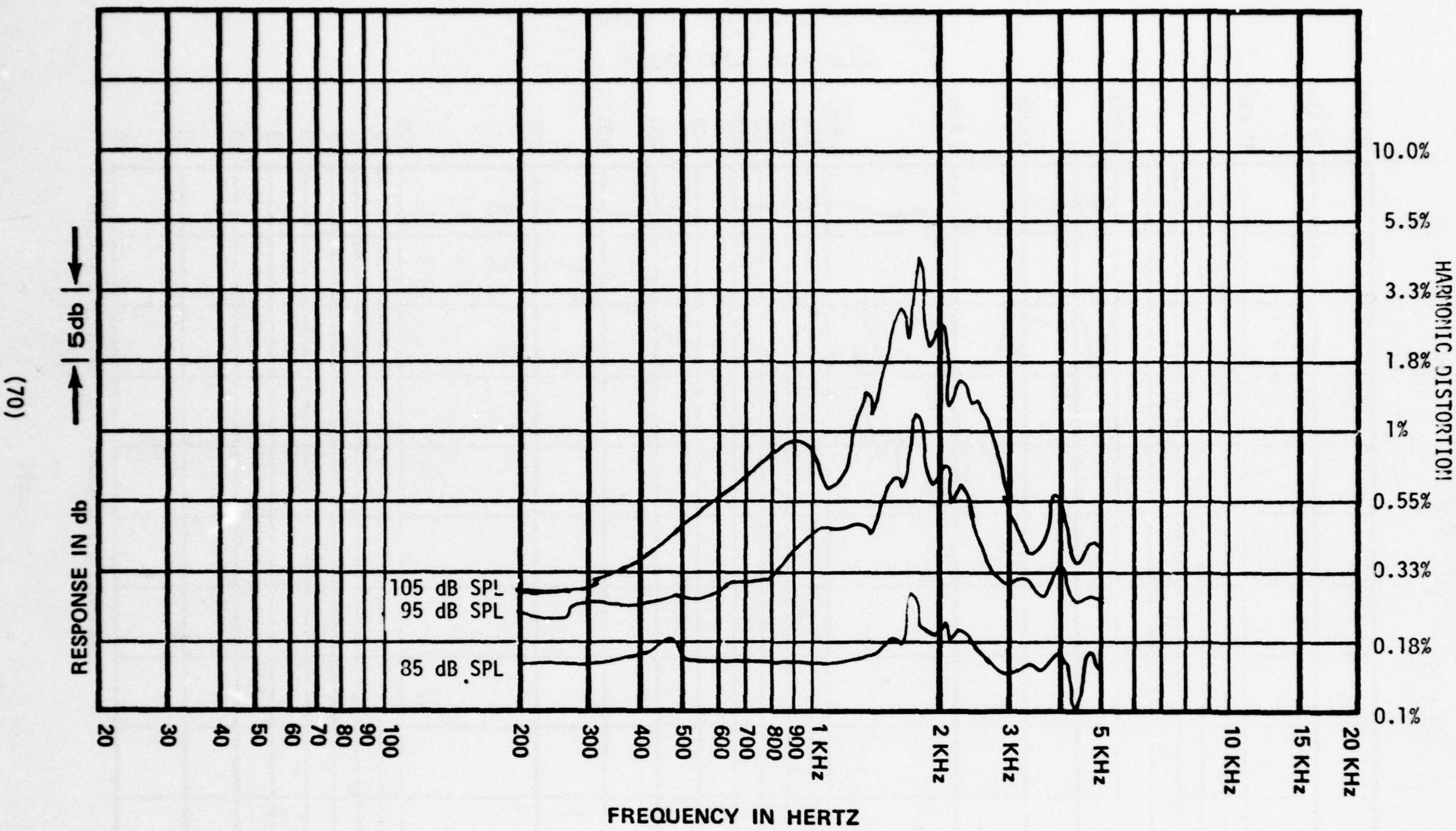
Unit #7 - Harmonic Distortion



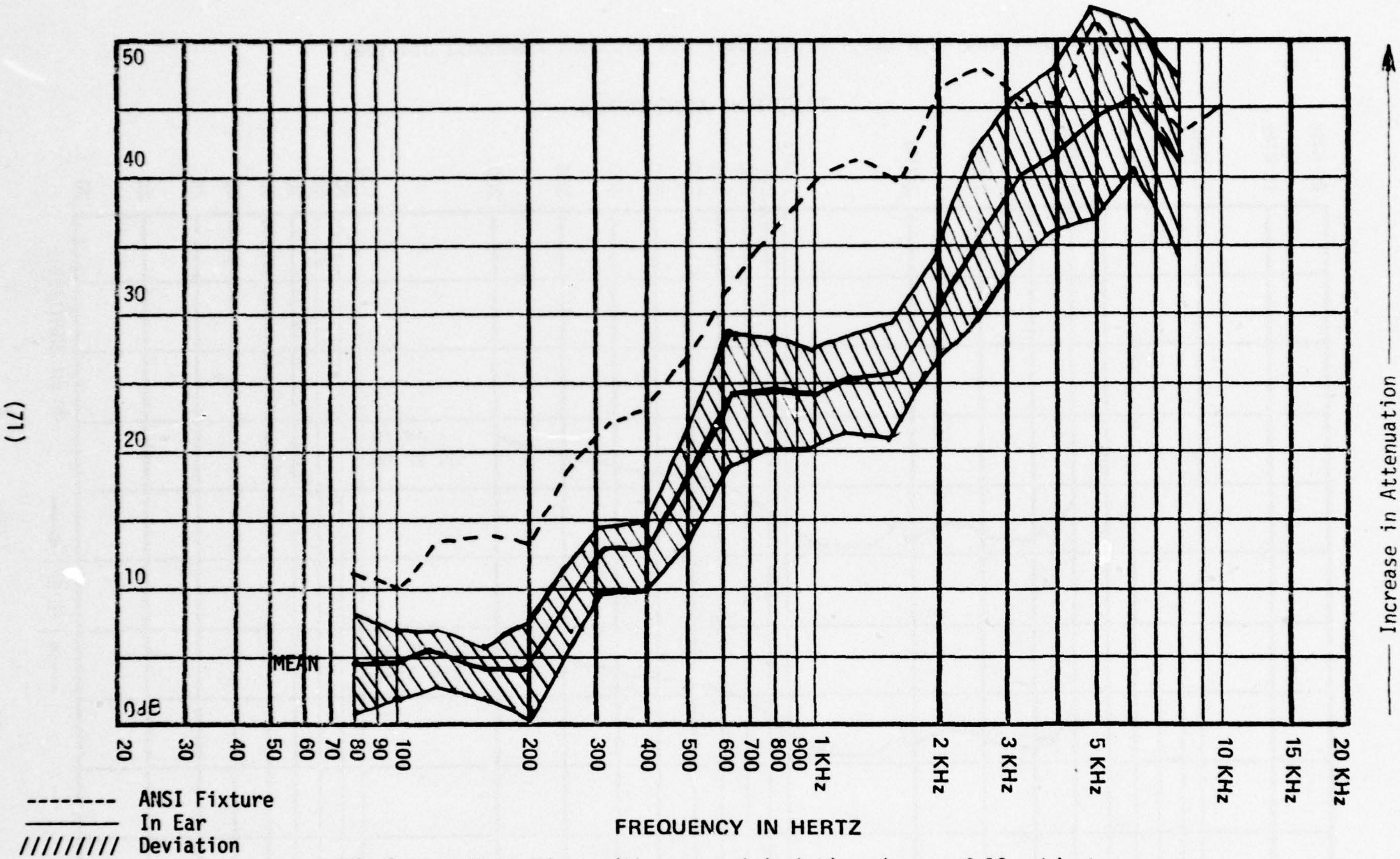
Unit #8 - Harmonic Distortion



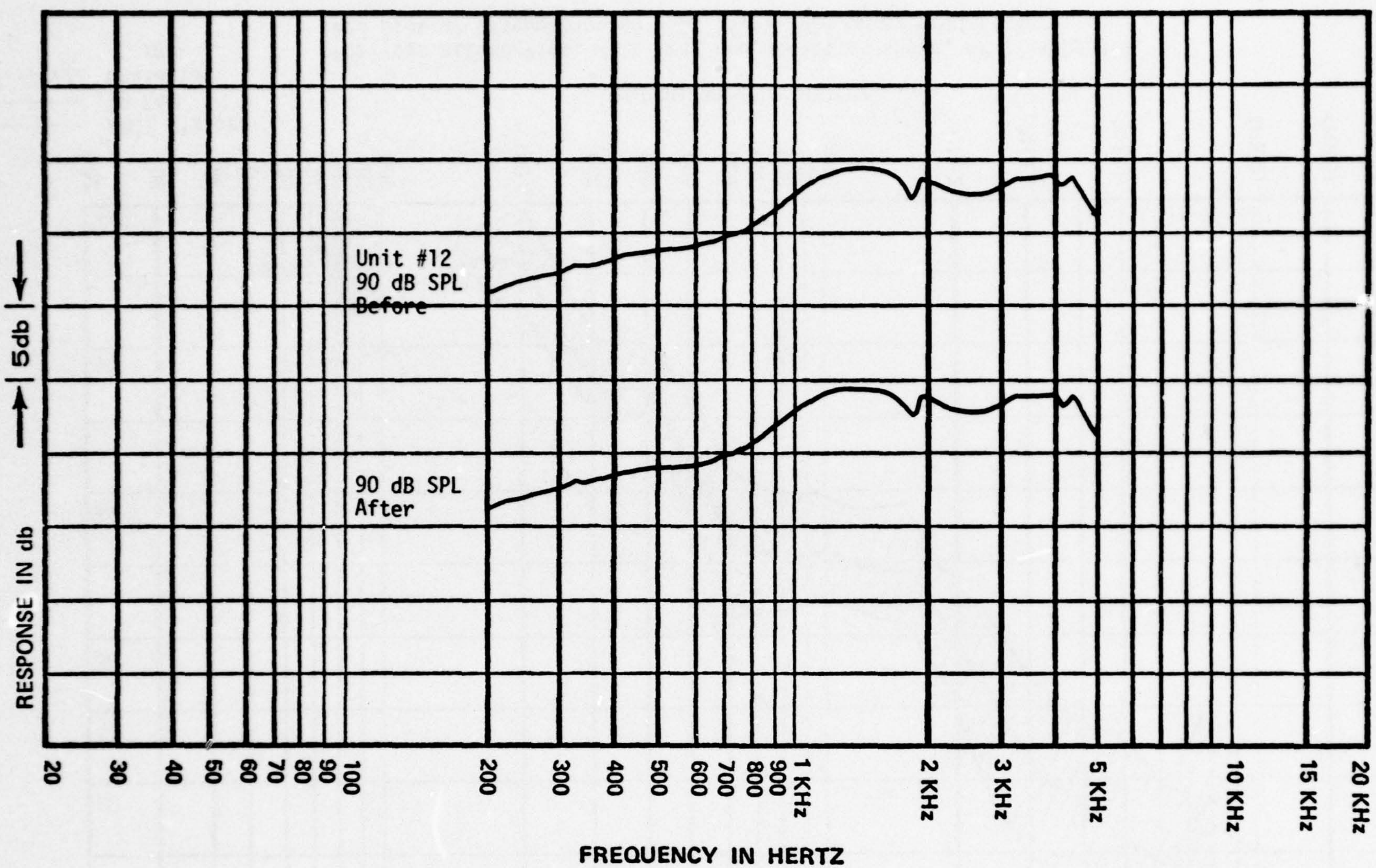
Unit #9 - Harmonic Distortion



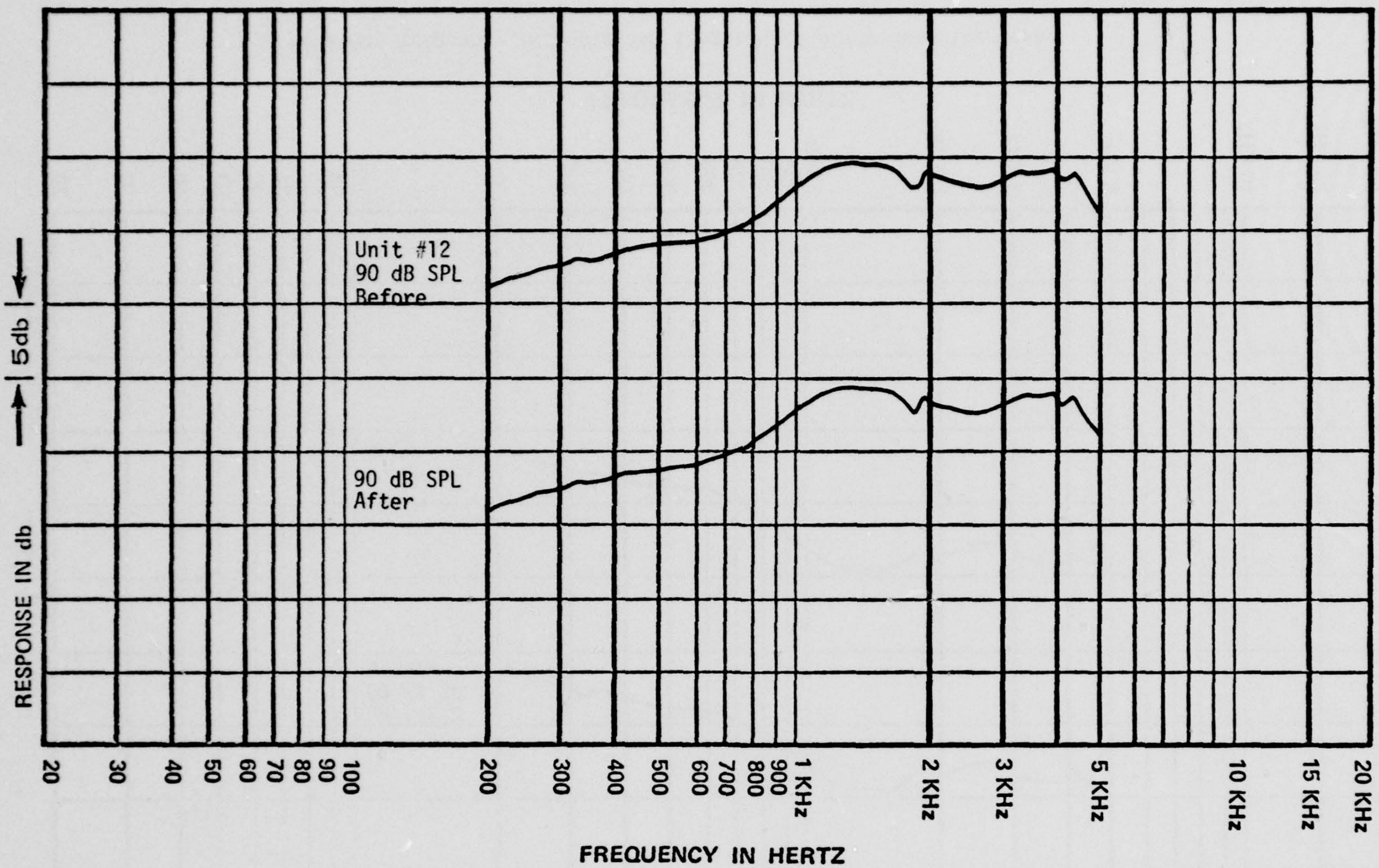
Unit #10 - Harmonic Distortion



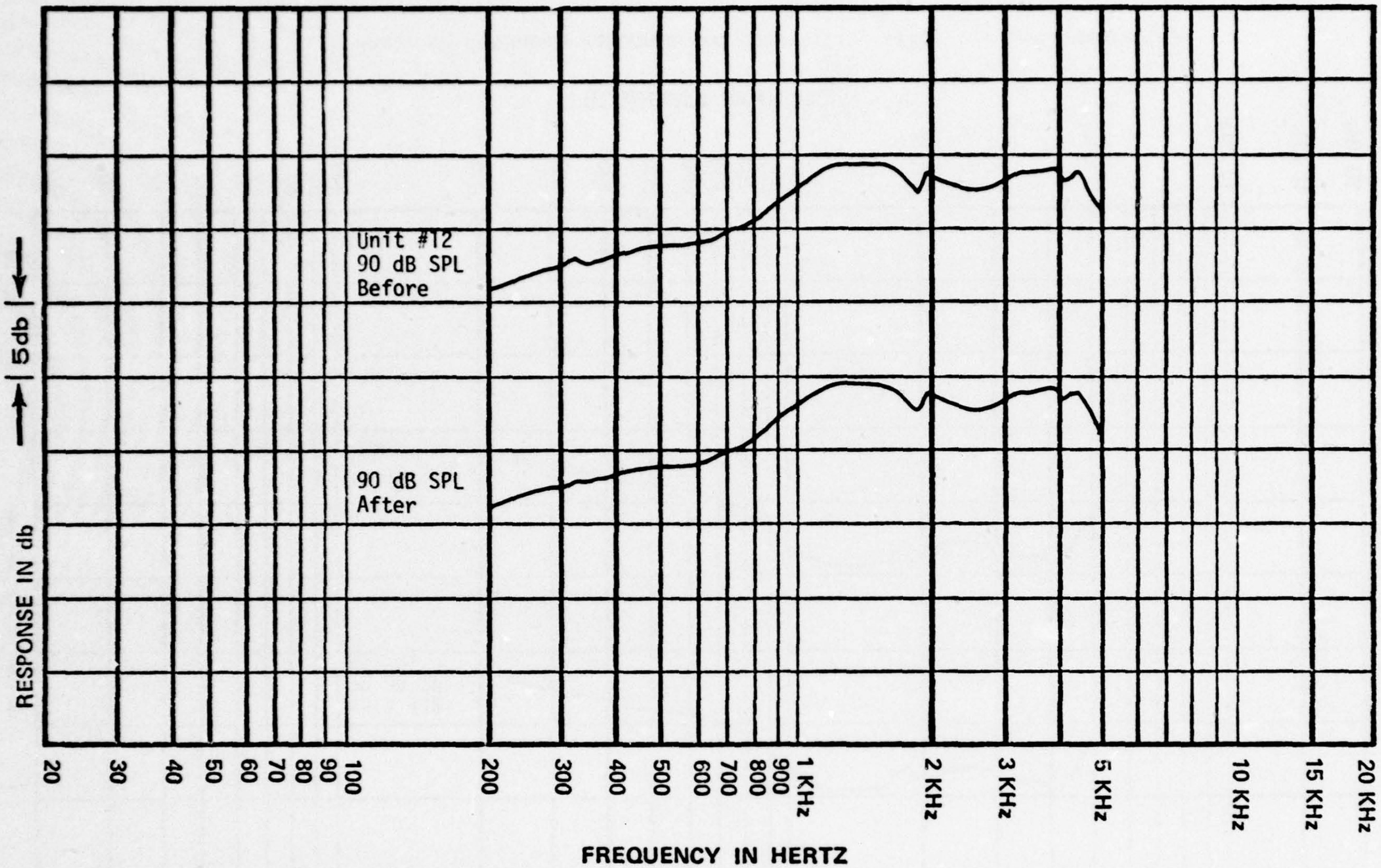
Real ear attenuation, with mean and deviation shown, of 12 subjects; and plot of attenuation on ANSI S3.19-1974 dummy head fixture.



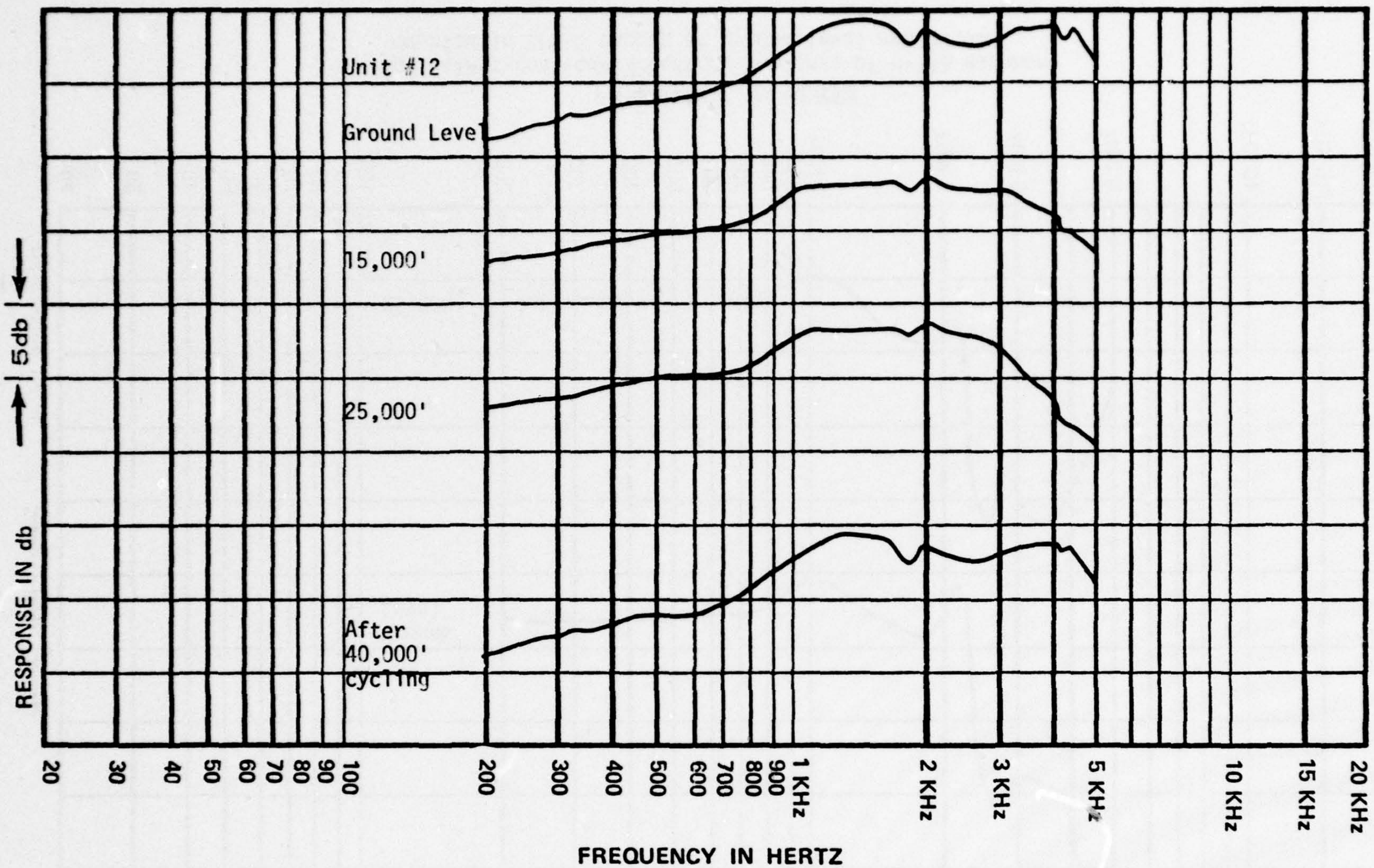
Real-ear frequency response and sensitivity after high temperature test.



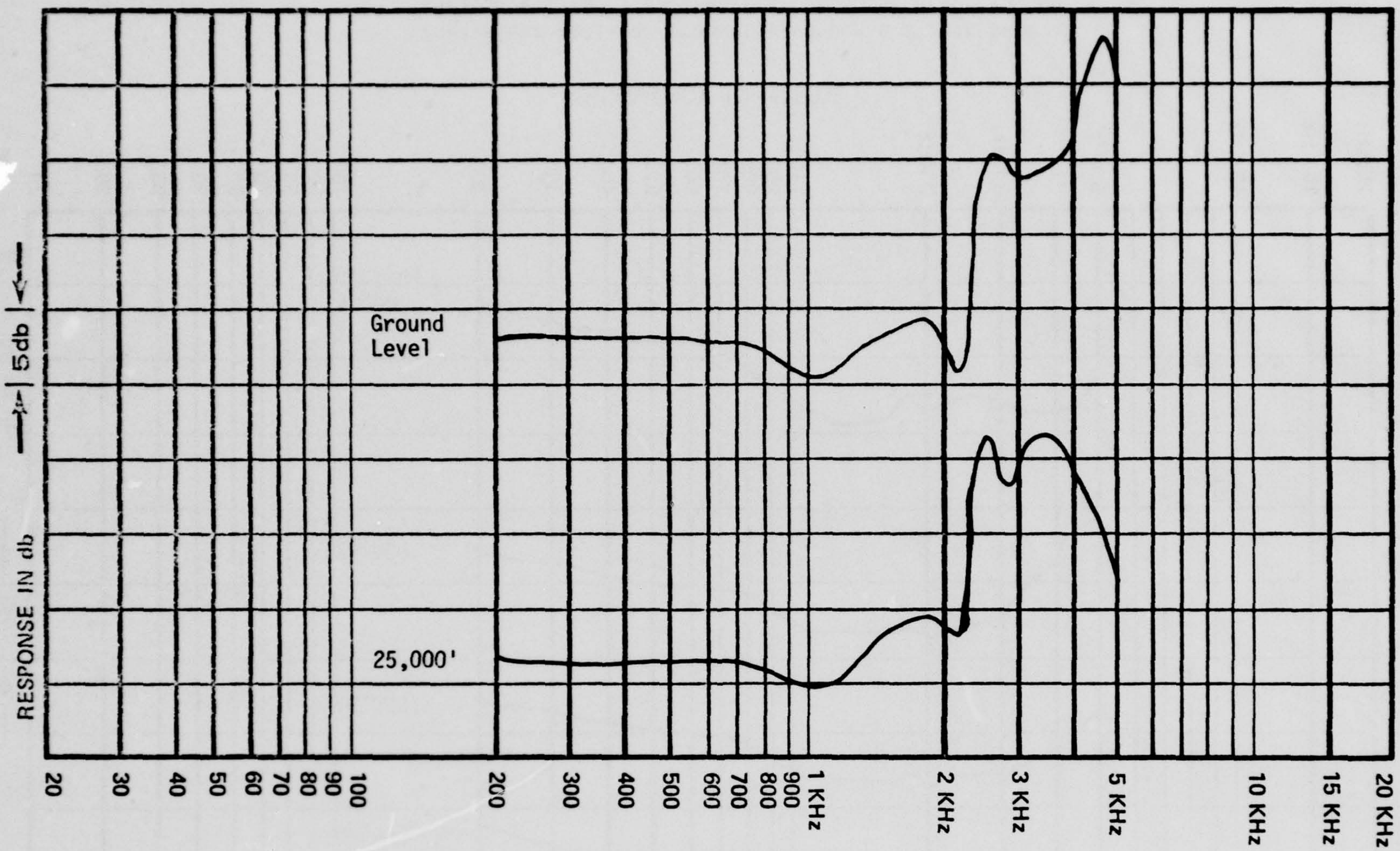
Real-ear frequency response and sensitivity after low temperature test.



Real-ear frequency response and sensitivity after humidity test.

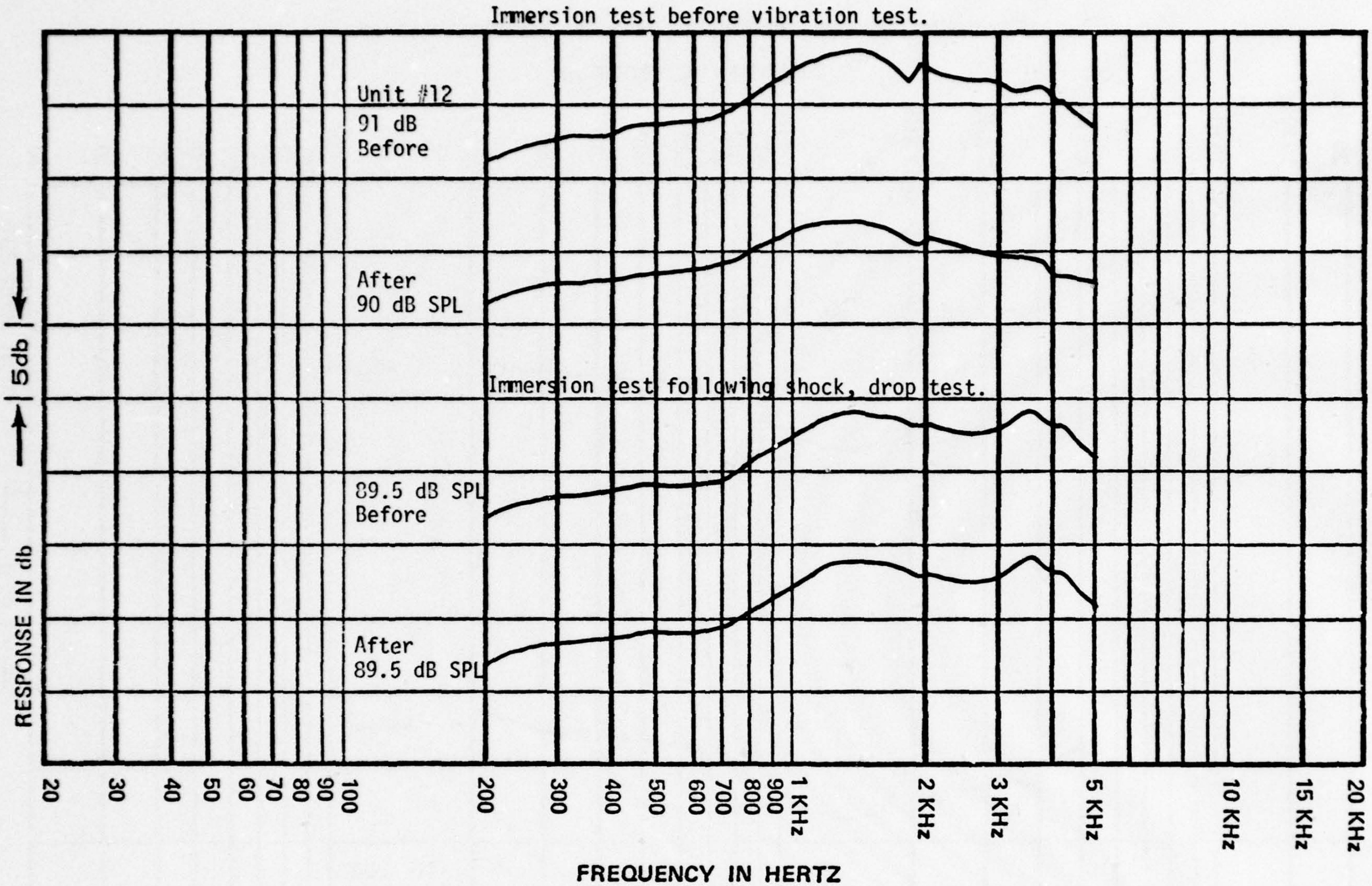


Equivalent real-ear frequency response of earphone at various altitudes and real-ear response after 40,000' altitude cycling.

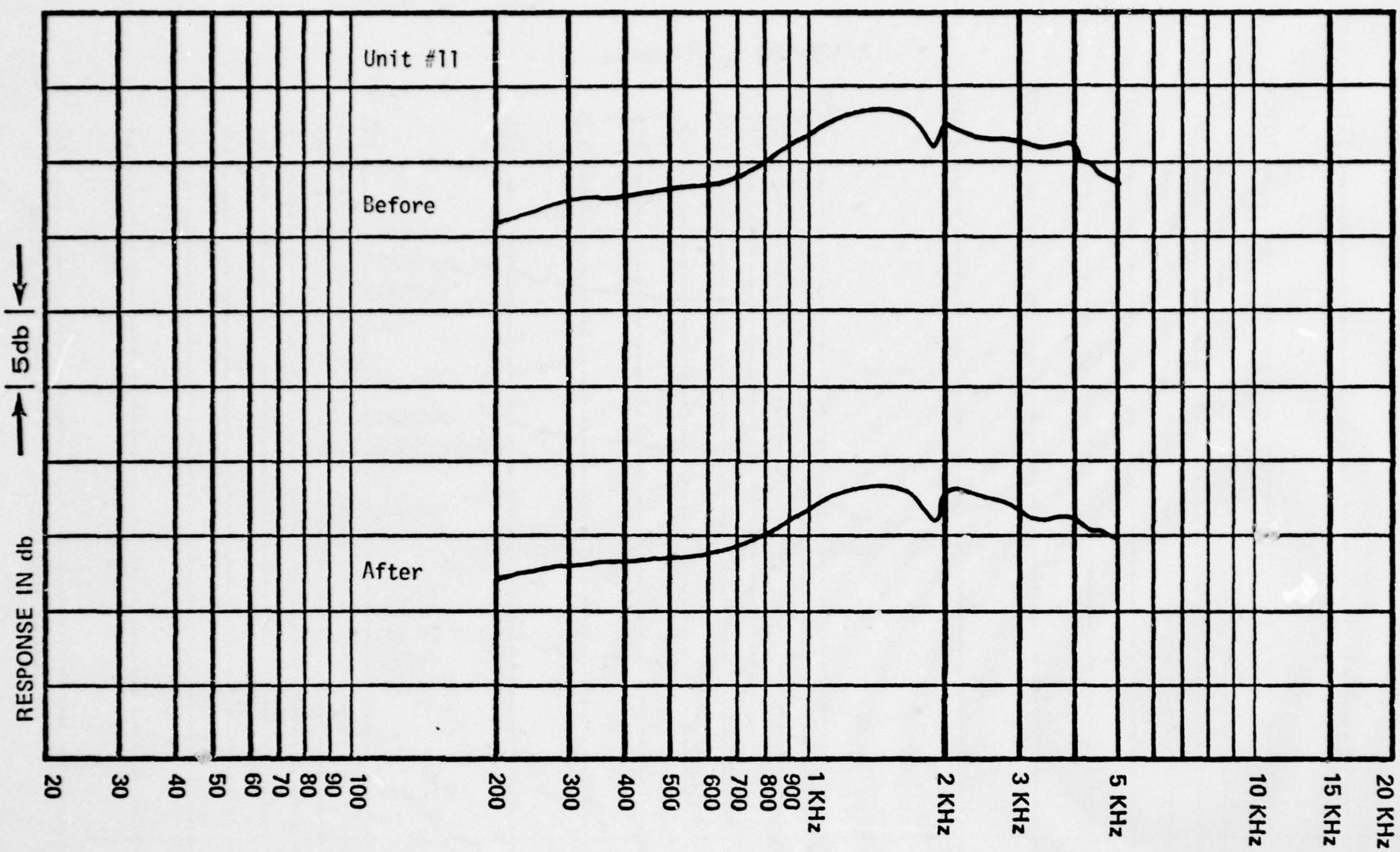


FREQUENCY IN HERTZ

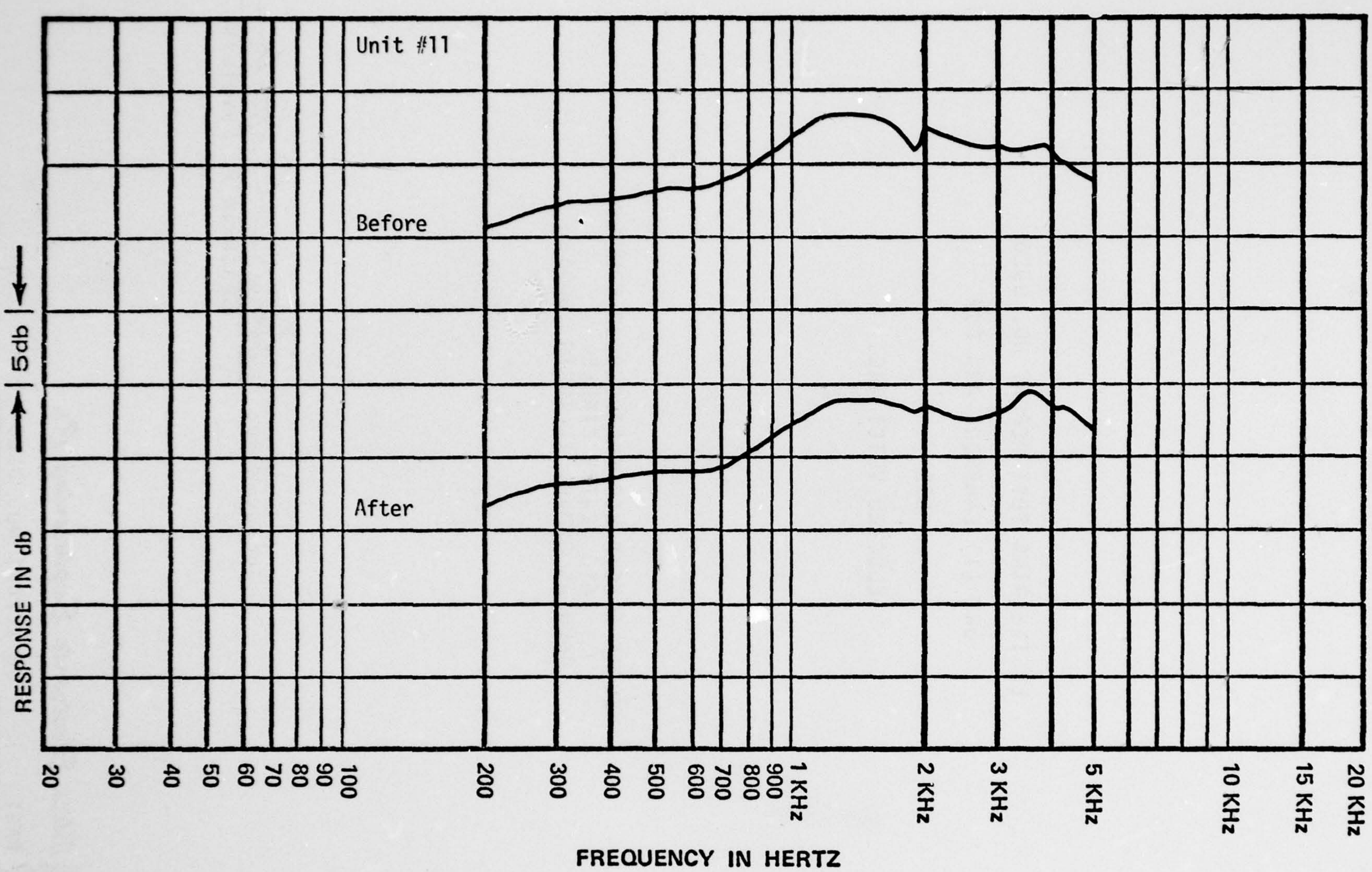
Equivalent real-ear frequency response of H-143 earphone mounted in SPH-4 earcup at ground level and 25,000'.



Real-ear frequency response and sensitivity after immersion test.



Real-ear frequency response of earphone after vibration test.



Real-ear frequency response of earphone after shock, drop test.

ENGINEERING TEST REPORT NO. 3980

ONE (1) EARPHONE AND CUP

FOR

ELECTRO VOICE INC.

ELITE ELECTRONIC ENGINEERING COMPANY
1516 CENTRE CIRCLE
DOWNERS GROVE, ILLINOIS 60515

Approved By: Benjamin F. Loveless

PURPOSE OF TEST: To determine if the specimen would support Fungus growth.

MANUFACTURER: Electro Voice, Inc.

MANUFACTURER'S TYPE OR MODEL NO.: One (1) Earphone and Cup

DRAWING, SPECIFICATION OR EXHIBIT: MIL-STD-810B

QUANTITY OF ITEMS TESTED: One (1)

SECURITY CLASSIFICATION OF ITEMS: Unclassified

DATE TEST COMPLETED: June 2, 1977

TEST CONDUCTED BY: Elite Electronic Engineering Company

DISPOSITION OF SPECIMENS: Returned to Electro Voice, Inc.

ABSTRACT: None - Data submitted for evaluation

DESCRIPTION OF TEST:

FUNGUS TEST

Requirements:

The test specimen shall satisfactorily withstand the Fungus conditions specified.

Test Procedure:

The test was conducted in accordance with specification MIL-STD-810B, Method 508.

A spore suspension was first prepared from the five (5) types of fungi listed below:

FUNGI

Chaetomium globosum

Aspergillus niger

Aspergillus flavus

Penicillium funiculosum

Aspergillus versicolor

A fresh spore suspension is prepared for each Fungus Test.

The test specimen was placed within the test chamber and sprayed with the suspension of mixed spores. The chamber was maintained at an internal temperature of 29°C and a relative humidity of 95 percent. The test specimen was allowed to remain under these conditions for a period of 28 days.

At the conclusion of the Fungus Test, the test unit was removed from the chamber and visually examined for evidence of fungus growth or deterioration as a result of fungus. The specimen was subsequently decontaminated.

DESCRIPTION OF TEST:

FUNGUS TEST (Cont.)

Description of Test Apparatus:

Fungus Chamber, Elite, Model 11-1010, S/N 113
Last Calibration Date: May 14, 1977

Test Results:

Visual examination of the test specimen revealed no evidence of fungus growth or physical change.

The specimen was returned to Electro Voice.

NOTE: The Viability of Inoculium Control Samples and Control Items (Filter Paper on agar, Vegetable Tanned Leather, and Cork bonded with protein glue) exhibited copious fungus growth.

ENGINEERING TEST REPORT NO. 3981

ON

ONE(1) EARPHONE AND CUP

FOR

ELECTRO VOICE INC.

ELITE ELECTRONIC ENGINEERING COMPANY
1516 CENTRE CIRCLE
DOWNERS GROVE, ILLINOIS 60515

Approved By: B. Loveless

B. Loveless

PURPOSE OF TEST: To determine the ability of the test specimen to withstand the Dust conditions specified.

MANUFACTURER: Electro Voice, Inc.

MANUFACTURER'S TYPE OR MODEL NO.: One (1) Earphone and Cup

DRAWING, SPECIFICATION OR EXHIBIT: MIL-STD-810 C

QUANTITY OF ITEMS TESTED: One (1)

SECURITY CLASSIFICATION OF ITEMS: Unclassified

DATE TEST COMPLETED: June 3, 1977

TEST CONDUCTED BY: ELITE ELECTRONICS ENGINEERING COMPANY

DISPOSITION OF SPECIMENS: Returned to Electro Voice, Inc.

ABSTRACT: None - Data submitted for evaluation

DESCRIPTION OF TEST:

DUST TEST

Requirements:

The test specimen shall satisfactorily withstand the Sand and Dust conditions specified.

Test Procedure:

The test was conducted in accordance with Specification MIL-STD-810C, Method 510, Procedure I.

The specimen was placed in the chamber.

The chamber temperature, air velocity, and dust density was varied as follows:

Step	Temperature	Air Velocity	Dust Density	Duration
1	23°C	1500-2000 FPM	0.1-0.5 g/ft^3	6 hours
2	63°C	100-500 FPM	None	16 hours
3	63°	1500-2000 FPM	0.1-05 g/ft^3	6 hours

The relative humidity did not exceed 10 percent at any time during the test. The sand and dust used in the test was of an angular structure and possessed the characteristics indicated within the governing specification.

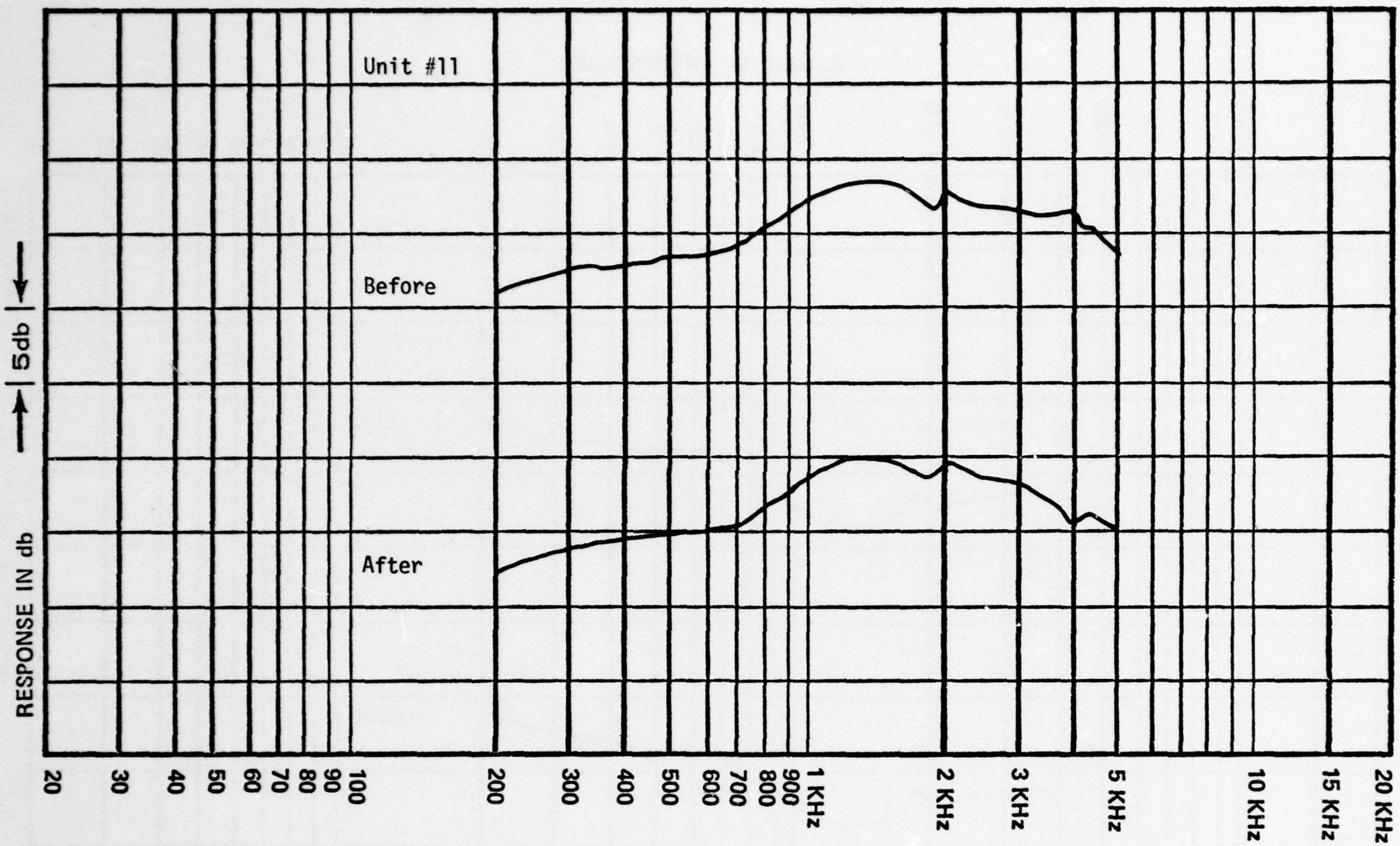
Description of Test Apparatus:

Sand and Dust Chamber, Elite, Model S-1024, S/N 120
Last Calibration - December 27, 1976

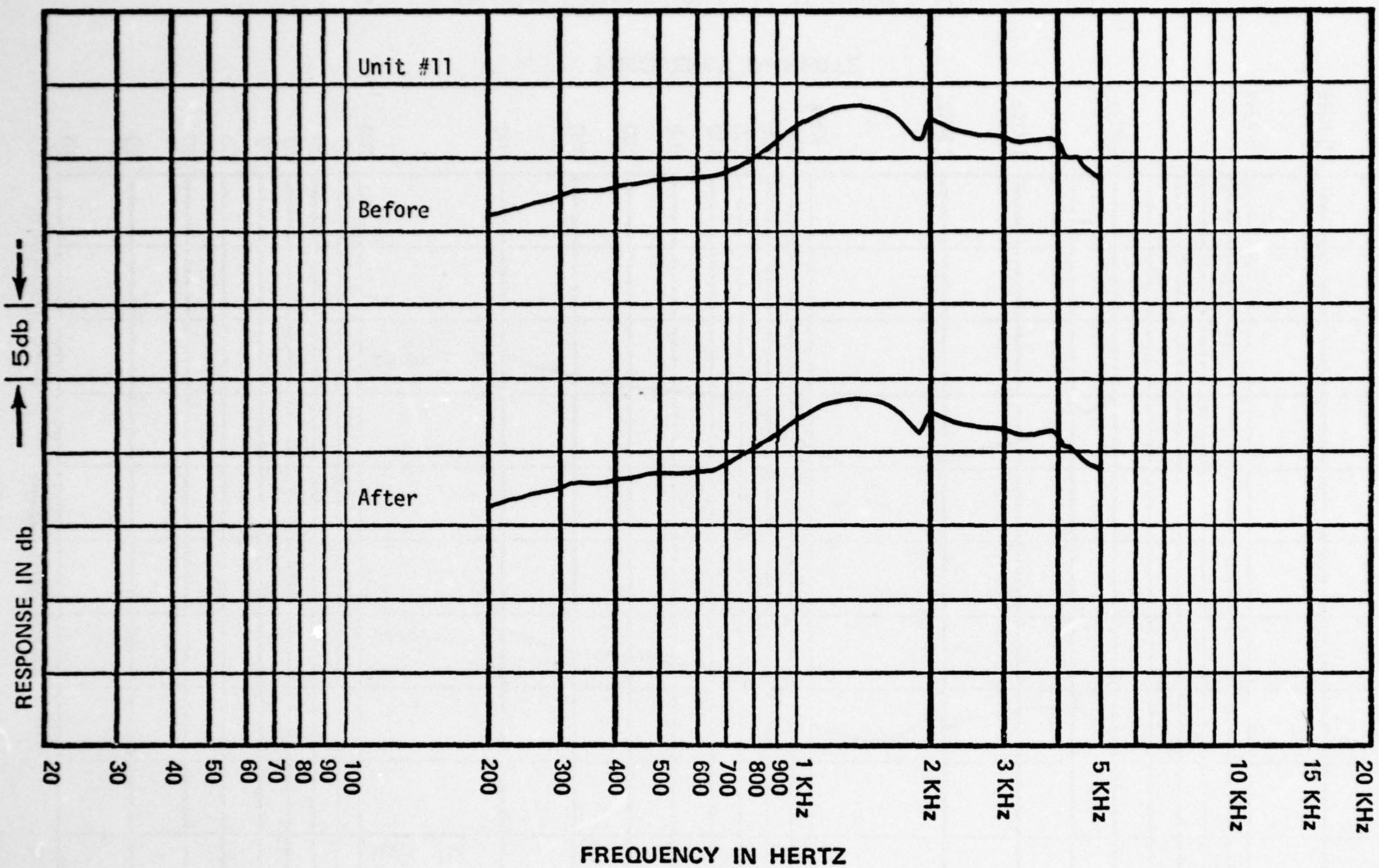
Test Results:

Visual examination of the test specimen limited to external surfaces revealed no evidence of physical change.

The specimen was then returned to Electro Voice.



Real-ear frequency response of earphone after dust test.



Real-ear frequency response of earphone after blast test.

TABLE OF PERCENTAGE OF TEST WORDS

Correctly Communicated in Intelligibility

Test to Determine Effects of Earphone Element Phasing

	% - correct *	
Subject	In-Phase	Out-Of-Phase
1	100	96
2	44	26
3	84	92
3	70	--
4	98	98
5	96	100
6	98	96
6	86	86
7	50	88
7	50	74
8	74	88
9	56	64
10	22	34
11	74	78
12	48	52
Mean	70.0	76.6
Deviation	24.0	24.0

*Notice the absolute percentage varies greatly as the subject was told to adjust the level for marginal intelligibility.

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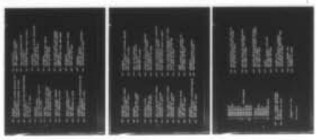

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